POWER

Volume 58 New York, August 7, 1923 *Number* 6

Pass Power Along

A FRIEND who started down the line and has arrived writes as follows:

> I read all parts of *Power* and enjoy it now quite as much as I did when I was merely a coal heaver in front of the boilers and could only get *Power* as I would take it surreptitiously off the chief's table; my chief in those days not being of the kind who believed in the advancement of the man at the bottom.

It has been the privilege of *Power* to help many men who were dependent upon their own efforts for their knowledge of the theory and principles of engineering.

We have tried to make *Power* the practical man's paper, to present in a plain and understandable way and in the language of the boiler and engine room those things which are taught and described in more abstruse terms in the textbooks and professional literature.

Many have been so kind as to say that we are particularly apt and successful at this, and that they owe to *Power* the aroused interest in engineering and the exposition of its fundamentals and development that has led to their progress and success.

A man who is thus interested, who has developed a thirst for engineering knowledge, a spirit of inquiry as to the bearing and significance of what is going on around him, a desire to better the record of the apparatus in his charge in efficiency, reliability or length of service is a real asset to a chief engineer.

The keeping up of his organization is one of the big problems of the man who is paid for keeping things done. The more the men whom he has about him know, the bigger and better engineers they are, the more smoothly and efficiently will his work progress and the better chief will he be.

And if they do outgrow the jobs that he has to offer them and pass on to bigger and better positions, is it not better to have a lot of friends who speak of you dearly as their Old Chief and credit their present worth to your training than to hold them back to avoid the trouble of breaking in other men?

Pass your *Power* along to the men under you when you have finished with it. Call their attention to particular articles that you think should interest them. Encourage them to discuss these articles with you after they have read them. You will find them becoming better men for your purpose, full of a spirit of loyalty to you and enthusiasm for your department that will insure the successful operation of the plant in your charge and make you a chief among chiefs.

And this is just as pertinent to the man in the office. Send *Power* to the engine room or power plant when it has been over the executives' desks. It will do good work for you over there at the same time that it is doing good work for your men.

F. R. Low

Industrial Power Plant of H. O. Wilbur & Sons, Inc. Philadelphia, Pa.

MODERN plant in the heart of the city, close to the Delaware River, replaces small engine-driven plant. The total generating capacity is 2250 kilowatts. Process steam is extracted from main units. Atmospheric cooling tower is mounted on roof.

BY J. HANLEY WILKERS*

IN THE very heart of historic Philadelphia there has grown a large industrial concern, the largest in that section and one of the largest of its kind in the country. Its product is chocolate and its byproduct cocoa, and so extensive did its business grow that H. O. Wilbur & Sons, Inc., found it necessary to abandon their small three-engine plant, with a total capacity of 375 kw., which furnished only a small portion of their needs and build a larger and more modern power plant. Designed in the early days of, and completed during, the World War, the engineers, contractors and the corporation itself were compelled to draw on all their resources and skill to bring about its completion promptly in order to meet the immediate demands.

Machinery to the value of several millions of dollars had been installed, but the original and somewhat antiquated plant had reached its limit. The local electrical company could supply no more power without laying additional and expensive lines the cost of which would have to be borne by the consumer. So the management decided that if the output was to be still further increased, a power plant was the practical solution.

The demands of the chocolate industry make this plant unique, for in it has been installed every unit necessary to supply every kind of power required to meet the many needs. To say that there are three 937-kva. turbo-generator units does not begin to describe the capacity of this plant. For in the manuufacture of chocolate very cold as well as very warm temperatures are required, and therefore two 150-ton capacity ice machines of the two-stage, feather-valve type are provided, as well as two 25-ton units.

Power of another nature—high-pressure oil—is employed to operate the heavy cocoa presses, which use 5,600 lb. pressure. Likewise air pressure is needed in various ways in the process, cleaning, etc., and two compressor units meet this requirement.

The building is 109 ft. long and 49 ft. wide, with a basement, ground floor and a mezzanine gallery. It is built of brick, structural steel and reinforced concrete. On the tiled roof is mounted an atmospheric cooling tower 139 ft. long and 22 ft. high. It has a capacity of 6,000 gal. a minute and is subdivided into seven units, six being used for condensing water and the other for the refrigerating gas condensers. It is the trough-deck system inclosed by patented galvanized louvers.

The boiler plant is served by a concrete stack 8 ft. in diameter at the top and rising 215 ft. in the air. It is lined the entire height with 4-in. hard-burned brick. There are no steps, and means of ascension are provided by a $\frac{3}{16}$-in. cable, circling through a pulley securely anchored at the top. Lightning is guarded against by

*Assistant Maintenance Engineer.

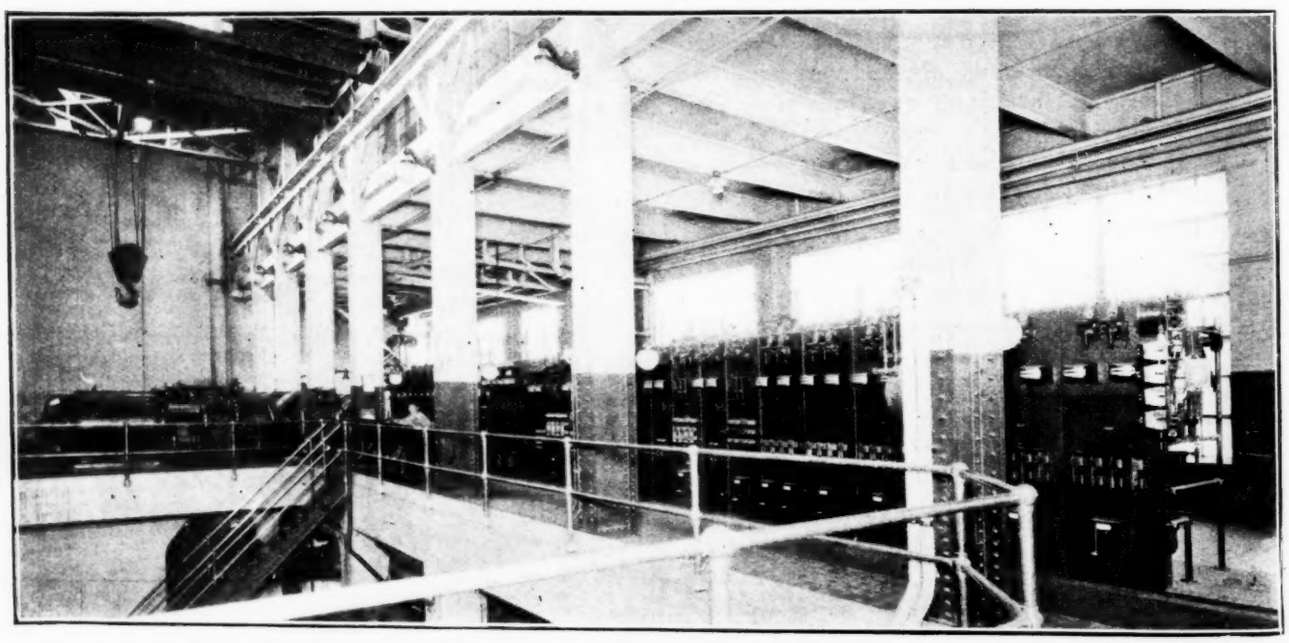
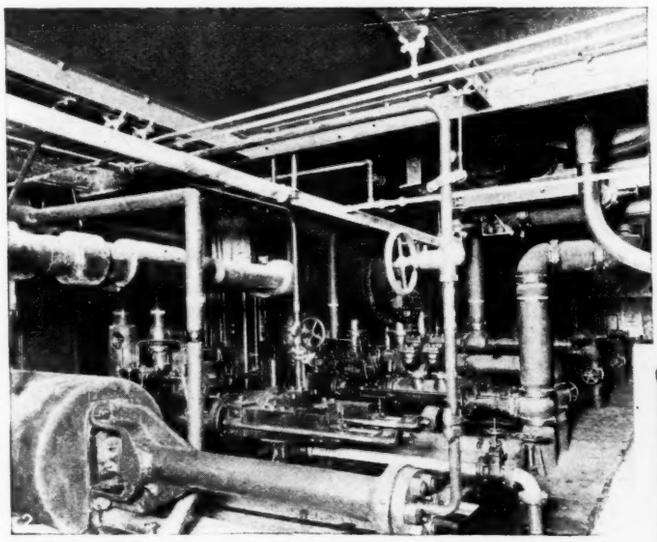


FIG. 1—VIEW OF TURBINE ROOM SHOWING ONE 750-KW. TURBO-UNIT AND STATION SWITCHBOARD



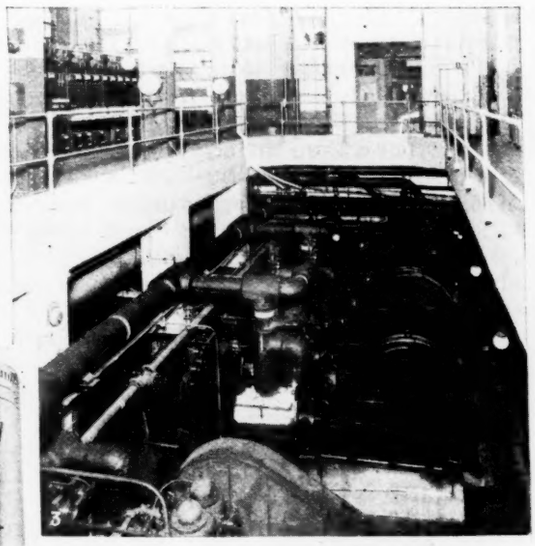


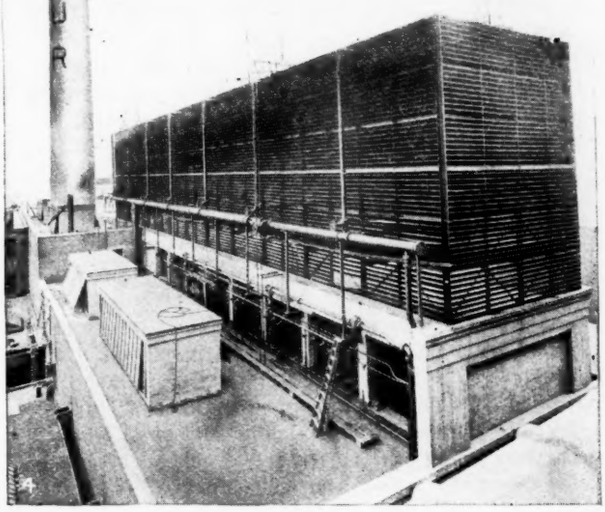
FIG. 2—SHOWS HIGH PRESSURE ACCUMULATOR, HYDRAULIC PUMP AND THREE FEED PUMPS, ALSO PARTIAL VIEW OF CONDENSER.

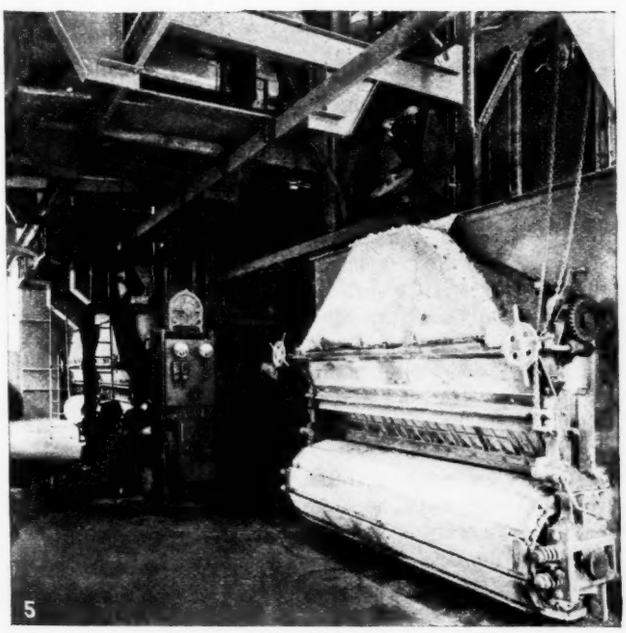
FIG. 3—TWO 160-TON COMPRESSORS DRIVEN BY SYNCHRONOUS MOTORS. CLEAR VIEW OF AUXILIARIES OBTAINED FROM TURBINE ROOM FLOOR.

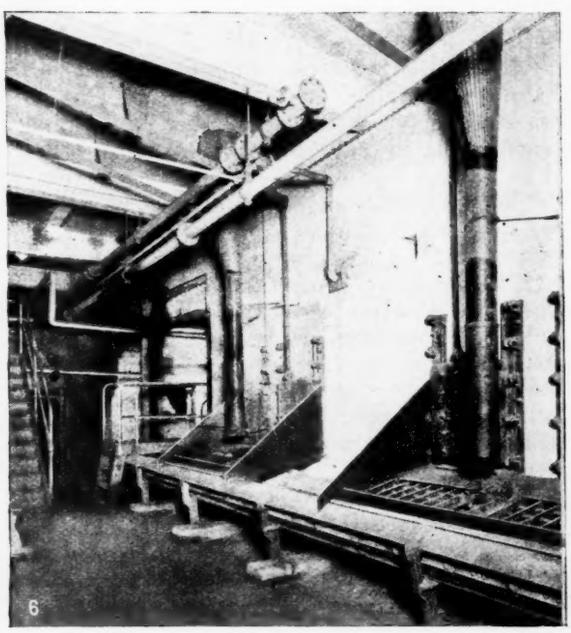
FIG. 4—THE ATMOSPHERIC COOLING TOWER FOR STEAM CONDENSERS AND REFRIGERATING SYSTEMS ON ROOF OF PLANT.

FIG. 5—FRONT VIEW OF BOILERS AND CHAIN GRATE STOKERS, ALSO FORCED DRAFT FAN AND CONTROL PANEL.

FIG. 6—ASHES ARE DRAWN FROM THE PITS DIRECTLY INTO BUCKET CONVEYOR.







the use of three copper-point rods ¾ in. in diameter, 8 ft. long. Each rod is tipped with a ½-in. white-gold thimble point. A copper circuit connecting these is completely wound around the stack at the top and a ⅝-in. cable conductor leads to the ground.

The boiler room is a part of the main building, but is separated by a 17-in. brick wall. Four boilers are provided for, but at present only three are installed. They are Stirling water-tube type with a heating surface of 5,016 sq.ft., built for a working pressure of 225 lb., and are set as battery and half battery. A safety-first water column, extension rods for stop valves on feed lines and for damper-operating mechanisms are furnished.

The boilers are equipped with convection-type superheaters designed to raise the temperature of the steam 120 deg. F. Indicating, recording, integrating flow meters measure the steam supplied by each boiler.

The stokers are of the forced-draft chain-grate type and are driven by individual 1½-hp. motors. The coal used is No. 3 barley anthracite averaging 11,500 B.t.u. per lb. Flat suspended arches are installed in each unit, and the settings are so constructed that they could easily be converted into oil burners.

Draft is supplied by two double-inlet heavy-duty fans, one of which is driven by a steam turbine and the other by a 120-hp. 1,200-r.p.m. 220-volt two-phase 60-cycle synchronous motor. Both are automatically controlled by damper regulators and are capable of operating the boiler at 300 per cent rating with 11,000 to 12,000 B.t.u. coal. The plant is equipped with the necessary CO_2 meters and other instruments for recording the operation of the boiler plant: mechanical soot blowers are installed in each boiler.

Coal Delivered by Motor Truck

Being situated a quarter of a mile from a railroad, in the midst of a closely built up neighborhood, it is impossible to get a railroad siding and coal must be handled daily. Further handicapped by lack of storage room, as every square foot is valuable and built on, the engineers were compelled to use the overhead space in the boiler room for coal and ash storage. Twenty feet was the available width, with a height of 14 ft. 6 in., leaving sufficient room to feed the stokers and for overhead mechanism. These coal and ash bins total 73 ft. in length and are supported on the main columns of the building. The bins are of plate steel. The two coal bins with a storage capacity of 11,000 cu.ft. (approximately 300 tons) are located on either end, while the ash bin is in the center. The latter is concrete lined to protect the metal and to make it fireproof and has a storage capacity of 4,500 cu.ft. (approximately 100 tons).

Coal is delivered to the plant by motor truck and is discharged into a hopper below the driveway along the south side of the building. From the unloading hopper an apron conveyor traveling at a speed of 20 ft. a min. and driven by a 3-hp. totally inclosed induction motor with moisture-proof insulation, delivers the coal to a bucket conveyor. The pivoted bucket system, which is capable of conveying 30 tons of coal or ashes an hour, is 32 ft. horizontal centers, 55 ft. vertical centers and operates at a speed of 50 ft. a minute. The conveyor is operated by a 10-hp. motor with compensator equipped with overload relays and low-voltage release coil arranged for remote push-button stopping and lockout button.

From the overhead coal bin the coal is passed to the stoker hoppers through automatic coal scales that are mounted on portable steel frames immediately under the bunkers.

City water is used and is supplied by 3-in. inlets from the city mains after passing through meters. It is then treated by a water softener with a capacity of 1,200 gal. an hour.

Meters in Engineer's Office Record Plant Operation

One horizontal feed-water heater designed for a working pressure of 10 lb. gage and a capacity of 10,000 gal. an hour is installed. The feed-pump installation consists of three 12x7½x10-in. duplex, outside packed, pot-valve plunger pumps. A water meter in the chief engineer's office measures all water supplied to the boilers. Overflow water from the heater is stored in a 5,000-gal. concrete cistern below the basement floor. Two other cisterns of the same capacity are located here, one for the storage of service water and the other for hot water.

The turbine room occupies the largest portion of the first floor and contains three turbo-generator units, two turbine-driven exciters, two motor-generator sets, rheostats and switchboard.

The turbines are of the horizontal impulse type and operate at 3,600 r.p.m. They are direct connected to 937-kva. 240-volt two-phase 60-cycle generators arranged for 250-volt excitation. The field rheostats are electrically operated. Steam for process is extracted from the main units under control of diaphragm valves. The turbo-driven exciters are 35-kw. 3,600-r.p.m. double-connected compound-wound machines arranged for non-condensing operation.

In order to supply current for the many direct-current motors already installed in the plant, two 2-unit, three-bearing motor-generator sets are provided, consisting of an 600-kw. 900-r.p.m. 250-volt direct-current compound-wound generator, mounted on a common base and driven by a 800-kva. 240-volt two-phase 60-cycle synchronous motor. The field rheostats are electrically operated. These units are provided with starting compensators, speed-limiting devices and arranged for 250-volt excitation.

Switchboard Located on Turbine Room Floor

The switchboard, which has a total length of 70 ft., is placed in front of and parallel with the areaway to basement, as shown in Fig. 1. Each panel is built of three 30-in. square sections of black Monson. It is equipped with the usual indicating and recording meters. All instruments are finished in dull black.

One 20-ton electric crane with hand bridge and trolley travel, 21-ft. 10-in. span and 35-ft. lift, runs the complete length of the turbine room and can handle the turbine parts and all basement condenser equipment.

One 15-ton trolley and hoist is provided for the motor-generator sets and is a close-coupled spur-geared triplex chain hoist with 12-ft. lift.

A 2,500-sq.ft. surface condenser is located immediately below each turbine. They are equipped with steam-jet air ejectors. An exhaust condenser heater is on the mezzanine gallery. The condenser pumps are motor-driven.

Cooling tunnels or boxes are required in a number of places in different parts of the factory for process work and cold storage, and several thousand feet of

pipe is necessary to carry the ammonia to these remote units. In addition a drinking-water system is provided in every building.

To take care of the large amount of refrigeration required, two 160-ton two-stage feather-valve type compressors are installed. These machines when operating at 200 r.p.m. are capable of handling sufficient ammonia gas to produce 144 tons of refrigeration, requiring 209 b.hp. at 25 lb. suction pressure and 185 lb. condensing pressure; operating at the same speed they can handle sufficient gas to produce 160 tons refrigeration requiring 235 b.hp.

The ammonia condensers which, as previously mentioned, are on the roof directly below the cooling tower, consist of two sets of drip-type condensers, each made up of 12 coils, 12 runs each, of 2-in. pipe 20 ft. long, with galvanized water-distributing troughs, with drip strips between the runs to lessen splashing from the coils. The ammonia receiver, which is in the basement, is 30 in. in diameter and 12 ft. long. The main supply line leading from the compressors is 8 in. in diameter. The drinking-water cooling system is also in the basement and consists of two coils, 18 runs each, of 2-in. extra-heavy pipe 9 ft. long galvanized outside only.

The 150-ton compressors are direct connected to

DATA ON PRINCIPAL EQUIPMENT IN H. O. WILBUR & SONS' PLANT

BUILDING DIMENSIONS

Length of turbine room, inside	104 ft. 4 in.
Width ot turbine room, inside	45 ft. 0 in.
Length of boiler room, inside	88 ft. 3 in.
Width of boiler room, inside	47 ft. 2 in.
Basement to turbine-room floor	17 ft. 0 in.
Turbine-room floor to gallery	19 ft. 0 in.
Distance turbine-room gallery floor to lower chord of roof truss	11 ft. 2 in.
Distance basement floor to boiler-room floor	15 ft. 0 in.
Distance boiler-room floor to lower chord of roof truss	33 ft. 4½ in.
Ratio of boiler-heating surface to boiler-house floor area	2.74 to 1

BOILERS AND SUPERHEATERS

Manufacturer	Babcock & Wilcox Co.
Type	Stirling
Number of boilers: Ultimate	Four
Installed	Three
Steam drums	Three—42-in. diameter 3 ft. 4½ in. long
Mud drum	One—48-in. diameter 11 ft. 7 in. long
Tubes	380-No. 9 B.w.g. 3½ in. outside diameter, arranged 15 high and 20 wide
Number of passes	4
Water-heating surface per boiler, sq.ft.	5,016
Boiler working pressure, lb. gage	225
Superheaters	Babcock & Wilcox Co.
Degrees superheat at normal rating	120

STOKERS

Manufacturer	Combustion Engineering Corp.
Type (Coxe)	Chain grate
Width of grate	9 ft. 8½ in.
Length of active grate	12 ft. 4 in.
Number of stokers per boiler	1
Grate area, sq.ft.	119½
Ratio of water-heating surface to grate area	42:1
Drive	1½ hp. motor
Motor manufacturer	Westinghouse Elec. & Mfg. Co.
Coal purchased	No. 3 anthracite buckwheat

BOILER SETTINGS

Height of center of steam drums from floor	26 ft. 6 in.
Height from stoker to nearest tubes	8 ft. 6 in.
Volume of combustion chamber	1,428 cu.ft.
Volume of combustion chamber per sq.ft. of active grate area	11.8:1
Arches, flat suspension, 1 per boiler	8 ft. 6 in. x 10 ft. 6 in.
Manufacturer	M. H. Detrick Co.

STACK

Builders	Heine Chimney Co.
Type	Concrete
Inside diameter at top, ft.	8
Height above grate, ft.	215
Ratio of chimney area to grate area (3 boilers)	1:4.18
Forced draft fans	Buffalo Forge Co.
Drive, one steam turbine	Terry Turbine Co.
one synchronous motor	General Electric Co.

MAIN GENERATING UNITS

Manufacturer	General Electric Co.
Number of units: Ultimate	Four
Installed	Three
Speed, r.p.m.	3,600
Generator	Direct-connected, 2-phase, 60-cycle, 240-volt
Capacity	750 kw.
2 Turbo-exciters	General Electric Co.
Capacity	35 kw.

Guaranteed performance main units. Operating conditions 215 lb. gage, 125 deg. superheat, 1 lb. abs. back pressure

Kw. Output of Generator	Lb. of Steam Per Kw.-Hr.
187	21.9
375	17.3
562.5	15.9
750	15.7
940	15.7

CONDENSERS

Manufacturer	Elliott Co.
Number: Ultimate	4
Installed	3
Type	Surface
Cooling surface, sq. ft.	2,500
Tubes ¾-in. x 13 ft. 3 in., No. 18 gage	Muntz metal

Condenser performance at 15,000 lb. steam per hour

Temp. Circ Water, Deg. F.	Vacuum, In.
70	28.5
80	27.9
90	27.3

COOLING TOIWER

Manufacturer	Edwin Burhorn Co.
Over-all dimensions	22 ft. wide, 139 ft. long, 28 ft. 10 in. high
Capacity, gal. per min.	6,000

REFRIGERATING EQUIPMENT

Manufacturer	Carbondale Machine Co.
Number	2
Type	Direct expansion—ammonia
Capacity	150 tons
Drive	205-kva. 220-v. 2-phase synchronous motors
Motor manufacturer	General Electric Co.
Manufacturer	York Mfg. Co.
Number	2
Capacity	25-ton
Drive	50-hp. 220-bolt 2-phase induction motor
Motor manufacturer	Westinghouse Elec. & Mfg. Co.

AIR COMPRESSORS

Manufacturer	Ingersoll-Rand Co.
Number	2
Capacity	One 145 cu.ft. per min., motor-driven; one-170 cu.ft. per min., steam-driven

FEED-WATER HEATERS

Number	One
Type	Open
Manufacturer	H.S.B.W.-Cochrane Corp.
Capacity, 40 to 200 deg. F. water per hour, lb.	75,000

BOILER-FEED PUMPS

Manufacturer	Worthington Pump & Machinery Corp.
Number	3
Type	duplex
Size	12 x 7½ x 10 in.
Capacity	130 to 280 gal. per min.
Discharge head	25 lb. above boiler pressure

MISCELLANEOUS EQUIPMENT

Hot service-water heater	Whitlock Coil Pipe Co.
Heating system wet vacuum pumps	Warren Webster & Co.
Sump pumps motor-driven	Goulds Mfg. Co.
Fire and Service Pumps	Worthington Pump & Machinery Corp.
Coal-and-ash-handling equipment	Jeffrey Mfg. Co.
Automatic coal scales	Richardson Scale Co.
Coal bunker	Jeffrey Mfg. Co.
Soot blowers	Diamond Power Spec. Corp.
Automatic non-return valves	Edward Valve & Mfg. Co.
Blowoff valves	Everlasting Valve Co.
Gaskets	Durabla Mfg.Co.
Throttle valves	Nelson Mfg. Co.
Feed-water regulators	"S-C" Regulator Mfg. Co.
Gate valves	Nelson Mfg. Co.
Reducing valves and traps	Schade Valve Mfg. Co.
Safety valves	Ashton Valve Co., Consolidated Safety Valve Co.
CO_2 Recorder	Uehling Instrument Co.
Steam pressure gages	United States Gage Co.
Recording pressure gages	The Foxboro Co., Inc.
Oiling system	S. F. Bowser & Co,, Inc.
Switchboard	General Electric Co.
Water-softening equipment	American Water Softener Co.
Traveling crane	Alfred Box & Co.
Damper regulator	Mason Regulator Co.
Pump governor	Fisher Governor Co.

PIPING

Piping furnished by Whitney-MacDonald Co., Philadelphia. All high-pressure piping extra-heavy, with Vanstone joints and welded outlets. Feed-water lines extra-heavy, with screwed cast-iron flanges and fittings. Exhaust and low-pressure piping standard. All over 6-in. Vanstone joints, under 6-in. screwed cast-iron flanges.

Pipe covering installed by Johns-Manville, Inc. All high-pressure pipe covering is double thickness 85 per cent magnesia. All feed-water lines single thickness 85 per cent magnesia. Feed-water heater 1-in. blocks and ½-in. cement. All covering is painted two coats to match building paint, and striped for identification.

Consulting Engineers: Scofield Engineering Co. Philadelphia

Building contractor Turner Construction Co.

200-hp. 200-r.p.m. 240-volt synchronous motors with electrically operated field rheostat and compensator, the motors being mounted directly on the compressor shaft. Two 25-ton compressors are also installed. These operate at 15.67 lb. suction pressure and 185 lb. condensing pressure and are driven by 50-hp. induction motors.

For certain processes high-pressure oil is required. The equipment for this service is in the basement. It consists of a special steam accumulator. Two special pumps are also furnished, one being a spare. They are automatically controlled by a governor and regulating valves.

Compressed air for the different services around the plant and factory is furnished by one 9x8-in. motor-driven compressor having a capacity of 145 cu.ft. per min. and by one inclosed-type steam-driven single-stage 9x8-in. compressor. This compressor is regulated by an adjustable speed governor and operates with medium-pressure steam.

Two underwriter's fire pumps 16x12 in. with a capacity of 750 gal. per min. are furnished. One is reserved for fire service, while the other is used as a factory service pump.

Circulating water for the ammonia condenser is supplied by two 3-in. double-suction volute pumps direct connected to 15-hp. 1,750-r.p.m. motors.

The factory cooling-water service is furnished by one 7x10-in. double-acting pump, brass fitted throughout and driven by a 10-hp. 1,200-r.p.m. slip-ring motor with starter and controller for speed reduction of 50 per cent. One 5x6-in. pump of the same type furnishes drinking water to the different fountains.

In addition to the pumps already mentioned, there are two 10x6x12-in. duplex pumps for makeup-water service and two 2x1½x2¾-in. duplex pumps for the automatic oil circulating system. For discharging the sumpage which is collected in wells at two points in the plant, two vertical motor-driven pumps are installed.

All superheated steam piping is open-hearth and tested at 1,000 lb. hydraulic pressure. High-pressure steam is maintained at 210 lb. gage, medium at 125 lb. and low at 5 lb. for heating purposes. Practically all high-pressure valves are extra-heavy steel, monel mounted.

All superheated steam piping 3-in. and over is covered by, first 1 in. of long-fiber asbestos plaster securely incorporated with wire netting and finished to a uniform surface. Then one layer of 85 per cent magnesia blocks 1 in. in thickness, so beveled as to make close joints between successive blocks and bound together. The joints are then filled with plastic cement. A second layer of the same size blocks, alternating the joints, is placed and finished with long-fiber asbestos plaster; 12-oz. canvas is then sewed on.

Piping under 3-in. has the same first application, but one 85 per cent magnesia covering of standard thickness is used instead of the blocks.

All covering adjacent to flanges is cut back a sufficient distance to permit dismantling without destroying the covering on the pipe lengths. Low-pressure steam lines are protected by standard thickness 85 per cent magnesia.

Ammonia piping was covered by first applying a special wrapping of canvas saturated with moisture-proof compound, then four complete layers totaling at least 4 in. of first-quality hair felt, all joints being staggered. This was secured by a membrane of spirally wrapped canvas saturated with a moisture-proof compound. The whole insulation was then covered with two layers of rosin sized paper and finished with 12-oz. canvas. The flanges were protected in the same manner as the steam.

All conduit leading from the generators to the switchboard and from there to the exit from the building is buried in the concrete floor. Both pipe and fiber are used. The plant is across the street from the factory buildings, and it was necessary to build a concrete tunnel 12 ft. wide, 10 ft. high and 25 ft. long under the street, through which is carried all conduit and pipe lines, and of course it is used as an underground entrance to the plant.

Hot water is supplied by a generator with a capacity of 1,000 gal. an hour, heating water from 40 deg. to 180 deg. with sufficient steam at atmospheric pressure. It has a storage capacity of 720 gallons.

Clean oil is stored in an overhead reservoir whence it flows by gravity to the turbines, ice machines, motor-generator sets and other auxiliary apparatus. The oil for the main units is supplied to each machine through a control valve and sight overflow indicator. The clean oil supplied to each turbine will displace a corresponding quantity of dirty oil from the bottom of the turbine reservoir which passes out through a sight overflow to the drain line.

All drain lines empty into a filter below, whence, after all water and impurities are removed, it is pumped back to the reservoir. Separate filters are provided for purifying ammonia oil and cylinder oil.

The engineer's office is equipped with two panels containing six 10-in. recording gages and a thermostat for reading temperatures in over forty locations through the plant and factory.

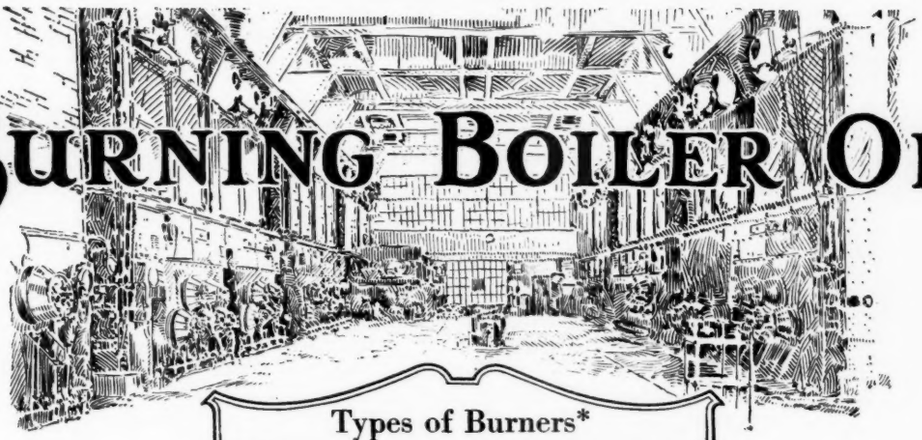
The plant was designed by and built under the supervision of the Scofield Engineering Co. The building was built by the Turner Construction Company.

A New Way To Demolish Foundations

Writing in the July issue of the *Power Engineer* (London), W. P. Walker describes a new type of hydraulic apparatus specially designed for demolishing concrete foundations in locations where the use of explosives would involve risk.

The apparatus is an adaptation of the hydraulic ram. A hole, about 4 in. in diameter and 3 ft. deep, is first drilled into the foundation with an air-hammer drill. Into this is inserted the "hydraulic cartridge," a cylinder about a foot long, from one side of which project eight small hydraulic rams. The hydraulic cartridge is connected to a small hydraulic cylinder with hand-operated screw pistons, by means of which a liquid pressure of from two to five tons per square inch can be obtained, with a resulting total side thrust on the cartridge of from 60 to 240 tons, according to the size of the machine. This force, it is claimed, is sufficient to break out the concrete in pieces as large as can be removed by a hand-operated hoist. It is stated that the apparatus may conveniently be used for the demolition of foundations under water.

Don't neglect ammonia leaks. Every week go over the refrigerating system with sulphur tapers. Be particularly sure to test for leaky joints in or opposite air vents, as these joints may leak badly but remain unnoticed because the ammonia fumes are carried away.



Burning Boiler Oil

Types of Burners*

WHILE it is necessary to have a reliable source of oil supply, ample storage facilities, piping, heaters and pumps, the efficiency to be obtained in the oil-burning boiler plants depends almost exclusively on the design of furnace and the type of burner. The most approved burner will fail to meet expectations if used in a furnace of improper construction.

Burners may be broadly classified as steam and mechanical atomizers. In the former class are those burners where the oil is broken up into minute particles by the action of a jet of steam. The mechanical atomizers are those that depend on the centrifugal force set up by the oil moving at high velocity in the burner tip to atomize or break up the oil into a fine mist.

The steam atomizer almost invariably gives a flat fan-shaped oil spray. The burner is usually placed as

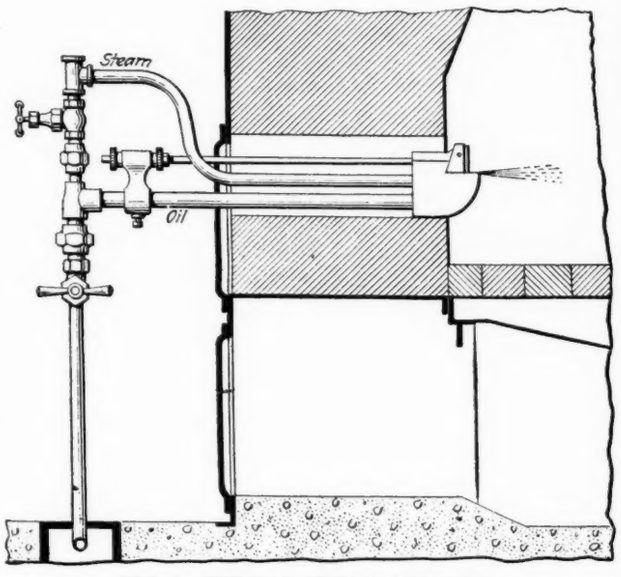


FIG. 1—TYPICAL STEAM ATOMIZER

low as possible in the furnace, and the spray is directed over a brick checkerwork making up the floor of the furnace. The air needed to support combustion enters through the openings in the checkerwork. In order to bring the air into intimate contact with the oil in the fan-like spray, the latter must be kept as thin as possible. If the spray becomes too thick, there is likely to be a deficiency of air in contact with oil, resulting in a falling off in furnace efficiency.

It is apparent that to obtain large capacity from a furnace it must have a large floor area; that is ,the furnace must be wide as well as long in order to provide

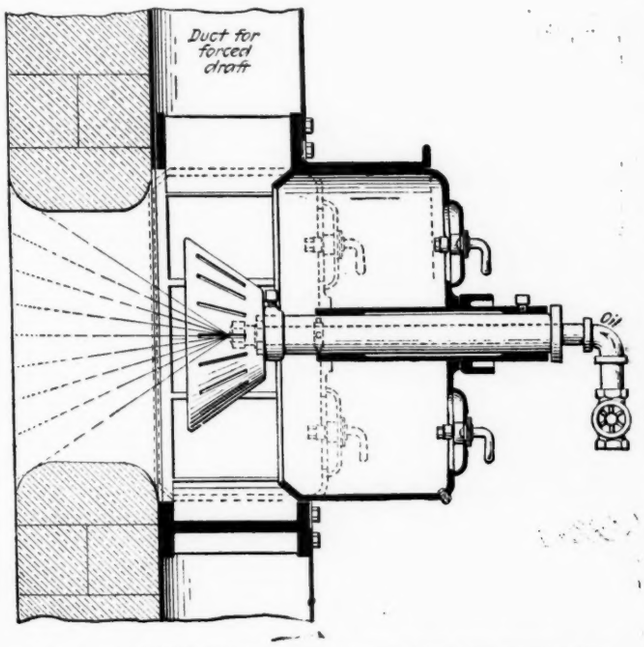


FIG. 2—MECHANICAL ATOMIZER AND AIR REGISTER

enough space for the thin fan-shaped spray and likewise enable sufficient air to enter through the checkerwork.

In many installations the furnace width is limited by the boiler-setting width, and to obtain a large capacity from the burners the furnace must be long. With a short furnace, even though of ample width, the flame length is such that combustion is not completed by the time the gases strike the tubes. This may result in blistering or other damage to the tubes.

Since there must be ample gas passage length between the tubes to absorb the heat of the gases, the furnace length is more or less limited. It will be observed, then, that both width and length of furnace are limited by the boiler design, and since area is of vital importance with the steam atomizer, it is generally understood by

*The first of a series of four articles. Various makes of burners will be described in the subsequent articles.

engineers that an evaporation of six pounds of water per square foot of boiler-heating surface is about as high as is possible to obtain with steam atomizers without a drop in efficiency.

It is possible to exceed this value greatly, but exceptional furnace conditions are required. One method of increasing the furnace capacity is by the use of back-shot burners, Fig. 4, whereby the oil, introduced into the furnace at the bridge wall, is directed toward the front of the furnace. This results in a longer flow path, as indicated by the flow lines in Fig. 4. An attempt is often made to obtain the same result by directing the flame downward at an angle with the horizontal.

Quite as necessary as area is furnace height. Increased height probably has little influence on combustion but, by increasing the flow travel, it lessens the danger of tube impingement.

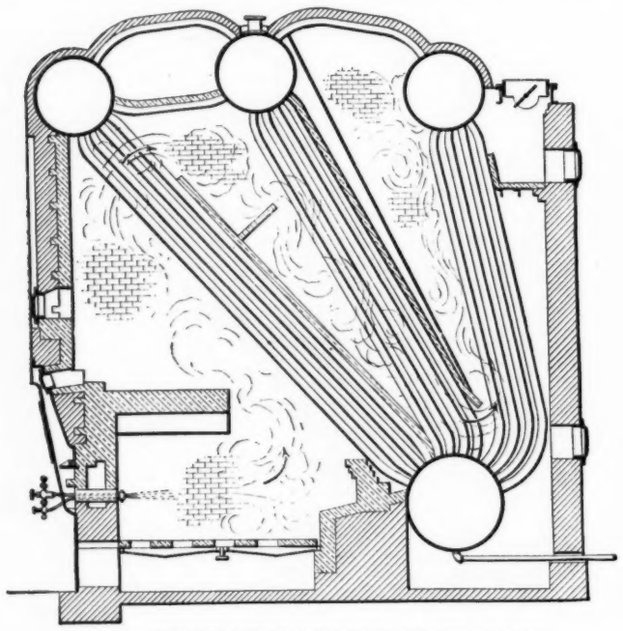


FIG. 3—FRONT-SHOT BURNER GIVES SHORT GAS TRAVEL

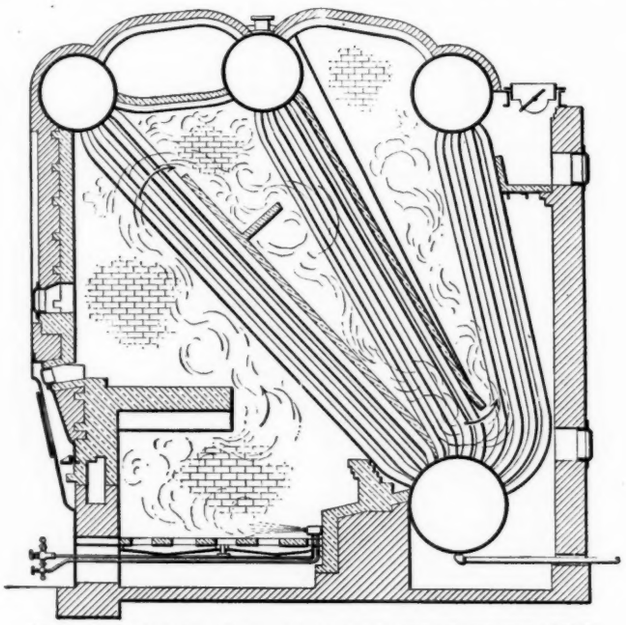


FIG. 4—LONG TRAVEL OBTAINED WITH BACK-SHOT BURNER

The first essential requirement to obtain satisfactory results from a steam atomizing burner is the production of a flame of such shape as to give proper distribution of flame in the furnace and practically to eliminate the excess air.

A second and important requirement is the reduction to the minimum of the amount of steam used for atomizing purposes. Burners have a wide range of steam demand, some taking 10 per cent and others but 2 per cent of the total steam evaporated in the boiler. Other requirements include simplicity and elimination of clogging or carbonizing of the burner tip.

For a number of years marine oil-burning installations have been using some type of mechanical burners. Primarily, this is due to the necessity of conserving the fresh-water supply. Some mechanical burners require as much steam to force the oil through the burner as is used by a steam atomizer, but in the mechanical burner the steam is used in the pump and is recovered in the condenser; with the second type the steam passes out of the stack in the flue gases.

The mechanical burner, as has been pointed out, causes the oil spray leaving the burner to be of conical form. For an equal oil-weight discharge this conical spray presents a greater surface area to the air that will a fantail spray. The spray length may then be shorter than when the steam atomizer is used, thus reducing the length of furnace required. By introducing the air through a register about the mechanical burner, it is not necessary to depend on the checkerwork on the bottom of the furnace for the air supply. While the statement does not apply to all burners, it appears that the conical spray is less destructive to the brickwork at high ratings, for the flame does not strike the brickwork if the burner is placed properly.

The mechanical burners may also be placed one above the other, provided the furnace height permits. The steam atomizer does not lend itself so readily to this arrangement since the air cannot get to the upper spray. The action of the steam atomizer induces an air flow much better than does the mechanical burner. For this reason a mechanical burner will require forced draft under conditions where natural draft would suffice for the steam atomizer.

The mechanical-type burner has until recently suffered from lack of flexibility. Since the spray is the result of the twirling action in the tip, a reduction in boiler demands requires a decrease in the oil flow. This must be brought about by a decrease in the rate of pumping. At a low oil flow the twirling action fails and the oil merely dribbles out of the tip. As a consequence, if conditions demand a wide range of furnace capacity, several burners were required. At low loads some of these were closed and frequently the oil in the tips of the idle burners charred and rendered the burners inoperative. Some late designs have overcome this very serious defect.

Both these systems have their advantages and disadvantages. The advantage of the flat-flame checkerwork system is largely in the ease of producing the spray. The oil may be handled at lower temperature and pressure, and the system is capable of widely ranging capacities without any special difficulty within their extreme limits. It is simple and when properly designed

gives excellent efficiencies, but has the disadvantage of the flame condition already mentioned, particularly at high ratings. Special equipment for high pressures and high temperatures is necessary with the mechanical system and, almost invariably, forced-draft fans. They need much closer and more expert attention. On the other hand, they will give an excellent furnace condition and high efficiencies at high ratings.

Operation of Semi-Diesel Engines

By T. C. Now

The semi-Diesel engine is found in thousands of small power plants. The success of this type is due more to the simplicity of the machine than to the care and skill of the operator. In fact, it is by no means unusual to find a plant where the engineer knows only how to start the engine and oil it occasionally, and the engine is left to itself to run quietly or noisily as conditions determine.

There are but few main points about the engine's care and adjustment that are vital, and it is unfortunate that engine builders as a whole do not go into them more completely in their instruction books. With these points thoroughly understood there should be no reason for engine failure.

Proper Lubrication Important

A semi-Diesel engine requires a certain amount of lubricating oil to be fed to the cylinder. By reason of the hot piston head, much higher in temperature than the pistons of gas or Diesel engines, there is a tendency to burn off the lubricating oil before the latter has done any service. It is necessary, then, to supply a greater quantity of oil to offset this evaporation. In the cylinder of any internal-combustion engine the lubricating oil on the cylinder walls is burned off during the firing or combustion stroke. If the amount fed to the semi-Diesel is too copious, only the top surface of the relatively thick wall film will be burned. There will remain a heavy, tarry coat which increases in thickness as the engine continues to drive. This gum has a high heat resistance and prevents the cooling water in the cylinder jacket from taking up enough of the heat developed in the cylinder to keep the engine conditions normal. As a result the piston cannot give up its heat and, becoming hot, expands and grips the cylinder walls. That just enough oil to lubricate the cylinder properly should be fed is evident.

Cooling water carrying much scale is likewise the cause of engine trouble. It is by no means unusual to find ¼ in. thickness of scale around the cylinder and once in a while a jacket becomes completely filled. The engine overheats and slows down owing to piston friction. The governor, acting on the pump plunger, injects more oil into the combustion chamber. The engine does not have enough air in the cylinder to burn this large oil charge, and part remains as a tarry mass on the walls of the cylinder.

If the timing is early, this hot condition of the engine will cause preignition and pounding. The remedy is to use non-scaling cooling water. Rain water is good, and in the absence of this in large quantities a pipe coil similar to an ammonia condenser may be connected to the system. The rain water is circulated through the tubes and raw water flows over the outside. Still another source of trouble is oil in the crankcase. Many semi-Diesel engines use the crankcase for the air-scavenging pump. If lubricating oil is fed to the bearings in excessive amounts or allowed to stay in the crankcase without being drained off, the churning of the air will cause the oil to float as a fine fog. This fog is carried into the cylinder, where it often leaves a deposit of carbon.

The crankcase often has an average temperature of 150 deg. F., and during the air-suction stroke the pressure in the crankcase drops below atmosphere. The heated oil vaporizes very rapidly under these conditions, and the vapor passes into the cylinder along with the scavenging air.

Why Some Semi-Diesels Refuse to Run Well at Light Loads

Some semi-Diesels operate on full or even half load satisfactorily, while refusing to run or running irregularly at light loads. This is caused by a cold combustion chamber or hot bulb. If water is used in the cylinder, the entire engine is designed to keep the bulb hot enough to fire the charge at light loads, while at full load the water keeps the bulb from overheating and cracking the oil. The operator need then merely adjust the water cock. Dry engines—that is, those not using a water jet—must be designed so that the combustion-chamber temperature is correct for full load. At low loads the heat absorbed by the hot surface if such be used, or the cylinder temperature if the engine depends on compression for ignition, may not be enough to ignite the oil. The engineer must light the starting plug with the torch as soon as the engine misses an ignition or two on a light load.

Since the hot surface must have a temperature above a definite minimum if ignition is to occur, the hot surface must be kept hot. This is possible when running light only by throttling the air going to the cylinder so that part of the burnt gases are left in the cylinder. This heated mass of gas serves to raise the cylinder temperature. Unfortunately, many engines do not have an air throttle and light-load operation is possible only by using a pilot charge which strikes the hot starting plug. Some types use a nozzle of a design such that the spray can be directed upon the starting plug. This plug is uncooled and maintains a high temperature regardless of the load.

Operators find that the exhaust ports tend to coke up with a tarry substance. This increases the back pressure, and in time the tar will be ignited by flames blowing out of the cylinder when the exhaust ports are uncovered. The resulting flames frequently show at the end of the exhaust pipe. The exhaust pipe should be examined once every two months and all carbon removed.

The two-stroke-cycle engines, which are in the majority, have exhaust ports around one half of the cylinder barrel. These ports are separated by bridges so that the end of the cylinder is a series of slots and bridges. The bridges often become very hot and may expand, taking a bow-like form. The piston or piston rings will strike these distorted bridges, in which case scores will appear on the piston. The bridges should be ground off to a level surface and the scores on the piston smoothed down with an emery wheel. There is little harm done even if the clearance is made very large as a result of this grinding.

Use of the Indicator on the Modern Ammonia Compressor

By G. E. PORCE

THE REAL dollar and cents value of the indicator in the compression refrigerating plant is not realized even today by many plant owners and managers, for it is seldom that an ammonia-compressor indicator is included in the engine-room equipment.

The actual taking of indicator diagrams from the compressor is very simple, the connection being practically the same as on a steam engine, and it can be readily done by the operating engineer with a little practice. Furthermore, the interpretation of the diagrams can also be just as readily done by the same engineer after a little study. The function of the indicator diagram is to show whether the compressor is operating properly. If a plant shows a falling off in capacity, any one of a number of things may cause the trouble. Unless the cause is evident, the compressor should first be carefully inspected, and the indicator affords the simplest and quickest means of determining whether the compressor is operating properly, and if not, the diagram points definitely to the defect.

What a Diagram Will Show

Even though a plant is apparently performing up to standard, it is quite important to indicate the compressor at regular intervals to be sure that power is not being lost by reason of leaky compressor valves or piston rings, sticking valves due to improper lubrication or spring tension, or cracked or broken valves. Practically all modern types of ammonia compressors except the smaller inclosed type machines are equipped by the manufacturers with connections and valves for an indicator; every specification covering a compressor should include this important item.

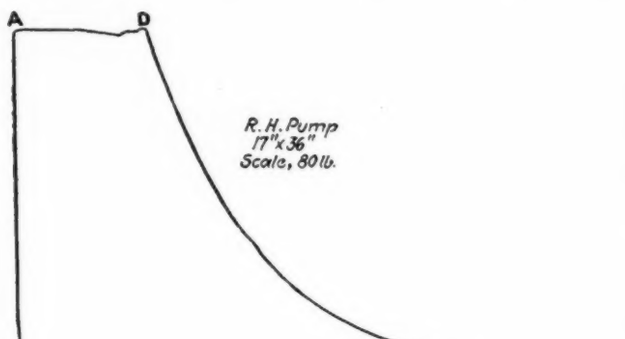


FIG. 1—DIAGRAM FROM A SLOW-SPEED COMPRESSOR

It is presumed that the reader is fairly familiar with indicator diagrams, and it is not the intention to go into detail regarding them, but rather to point out some of the serious compressor faults which the indicator diagram will reveal and how simple the correct interpretation of the diagram really is. However, since ammonia attacks brass, the indicator should have a steel barrel, or if a brass-barrelled instrument only is available, it should be removed and thoroughly cleaned as soon as the diagram is taken.

The indicator diagram does not give directly the capacity of the compressor in tons of refrigeration. The area of the diagram, however, is an exact measure of the indicated horsepower being used by the compressor, and on each type of compressor are data available (these data can be secured from the manufacturer) giving the approximate compressor indicated horsepower per ton of refrigerating capacity at different suction and discharge pressures; the approximate refrigerating capacity the compressor is producing can be obtained by dividing the indicated horsepower as determined from the diagram by the indicated horsepower per ton refrigeration.

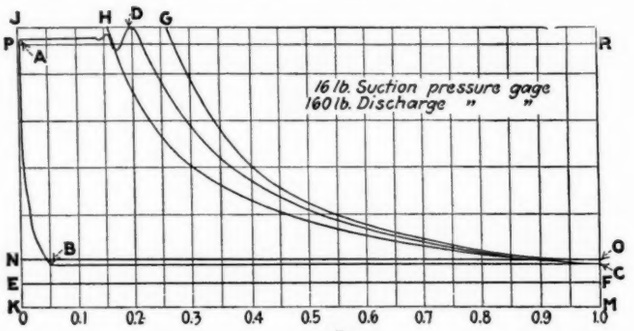


FIG. 2—CONSTRUCTION OF ADIABATIC AND ISOTHERMAL COMPRESSION LINES

Typical Indicator Diagrams

The plant engineer should hold in his reference file indicator diagrams taken from his compressors when they were first installed and were meeting capacity guarantees. With these diagrams as a guide he can later soon detect any defects that may develop.

Fig. 1 is a reproduction of an actual diagram from a slow-speed vertical single-acting compressor. The point *A* on the diagram was made by the indicator pencil at the end of the compression stroke, in this case just as the piston reached its point of maximum travel at the top of the cylinder. All the cylinderful of gas has been discharged into the condenser at the point *A* except that which remains in the clearance space. The line *AB* is the clearance volume expansion line, this volume of gas expanding back to the point *B*, at which point the suction valve opens. *BC* is the suction line, the cylinder filling with gas along this line and the suction valve closing at *C* just as the compression stroke begins. The line *CD* is the compression curve, the piston compressing the gas to the point *D* at which the pressure in the cylinder is sufficient to open the discharge valve. The compressed gas is discharged into the condenser along the line *DA*. The line of atmospheric pressure *EF* is made by turning the indicator cock so that the indicator is open to the atmosphere.

After the plant engineer is familiar with the normal

diagram the compressor should give, he can readily tell a number of things from a study of the diagram. For instance, Fig. 1 shows that the compressor has practically no clearance volume, since the line *AB* drops almost vertically in each case and the suction valves open very soon after the stroke begins—all as it should be for this type of compressor. The diagram further reveals that the compressor is probably operating properly; however, it is necessary to go a few steps farther in order definitely to determine the valve action, etc.

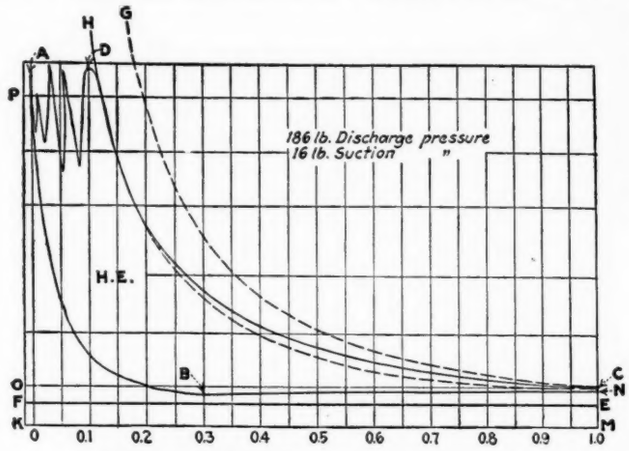


FIG. 3—DIAGRAM SHOWS UNSATISFACTORY PERFORMANCE

Most modern ammonia compressors are operated on what is termed dry-gas compression; that is, only dry gas enters the compressor cylinder. Now for dry ammonia-gas compression the compression is practically what is called adiabatic—meaning that the compression takes place without any loss or gain of heat to or from outside sources—and follows the equation $p_1 v_1^{1.29} = p_2 v_2^{1.29}$, the exponent 1.29 being the ratio of the specific heats of ammonia gas. Now refer to Fig. 2, which is a diagram from a modern vertical, single-acting high-speed ammonia compressor. As before, the line *EF* is the atmospheric pressure line drawn by the indicator pencil when opened to the atmosphere. We will now proceed to lay out the line of adiabatic compression for this diagram, which theoretical line will show us a number of things.

Constructing the Adiabatic

Measure a distance proportional to 14.7 lb., the atmospheric presure, below the atmospheric line *EF*, using the scale of the indicator spring, and draw the zero pressure line *KM* parallel to *EF*. Then draw the line *JK* perpendicular to *KM* and just touching the extreme left-hand corner of the diagram. The clearance can be disregarded as it does not materially enter into the results when the machine is single-acting and has a small clearance. The zero pressure line *KM* is equal to the over-all length of the diagram or the full stroke of the compressor. Divide this line into ten equal parts with a pair of dividers and number each division by tenths from 0 to 1, as shown. Now the problem is to determine the adiabatic pressures corresponding to the different volumes we have laid off on the zero line *KM*. If p is the absolute suction pressure, measured by the distance *CM*, at the point where compression begins and at which the cylinder is filled with gas, then we can assume $v = 10$ parts for this point and substituting in the thermodynamic equation for adiabatic compression, we have $p \times 10^{1.29} = 1.33\ p_1 v_1^{1.29}$, where p_1 is the pressure at any point on the adiabatic curve corresponding to any volume v_1 on the zero line *KM*. Now from this equation we can readily obtain the points on the adiabatic curve p_1, p_2, p_3, etc., corresponding to v_1, v_2, v_3, etc., for any diagram.

To determine the value of p_1 etc., it is unnecessary for the plant engineer to use the formula, as the table shows the relation of the pressure at any volume point to the suction pressure. As example, after dividing the diagram length into ten equal sections, the adiabatic pressure at the volume point 7 is seen to be 1.584 times the suction pressure in pounds per square inch absolute. Always work in absolute pressures and measure the pressures from the zero line, using the scale of the indicator spring.

Volume Vol. Pt.	Adiabatic Curve p/p_s	Isothermal Curve p/p_s
10	1	1
9	1.146	1.111
8	1.333	1.250
7	1.584	1.428
6	1.932	1.666
5	2.453	2.000
4	3.26	2.50
3	4.726	3.333
2	7.974	5.000
1	19.5	10.000

After the adiabatic curve *CG* for a diagram has been plotted, one can tell a number of things. If the compression curve of the diagram does not follow the adiabatic curve fairly closely, something is wrong. The compressor cylinder water jackets do remove a small part of the heat of compression, so that the compression curve of the card will fall slightly below the adiabatic. It can never lie above the adiabatic unless the high-pressure gas is leaking past the discharge valves or the gaskets or leaking into the cylinder. If the compression curve of the diagram falls too far below the adiabatic curve, it shows that the suction valves or their gaskets or the piston rings are leaking.

Isothermal Compression

Now let us draw in the isothermal curve *CH*, which is also useful in interpreting a diagram. The isothermal compression of a gas is compressing it at a constant temperature. If it were possible to remove all the heat of compression from the cylinder walls, heads and piston of an ammonia compressor and compress the gas at its suction temperature without any increase in temperature, we would be compressing it isothermally. This would be the ideal compression since the minimum

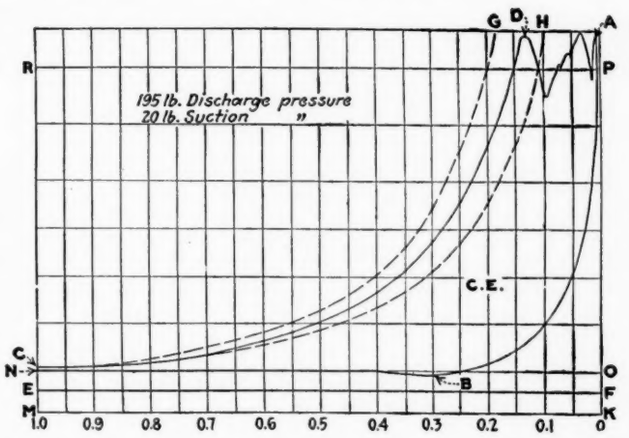


FIG. 4—CRANK-END DIAGRAM FROM SAME COMPRESSOR AS FIG. 3

amount of work would be required with it. The isothermal equation is $p_1 v_1 = p_2 v_2$. Using the same points on the zero line as were used for the adiabatic and multiplying the absolute suction pressure by the ratio given in the table under isothermal compression enables one to construct this curve.

After plotting the adiabatic and isothermal curves, two more useful lines should be drawn, namely, the line *NO* corresponding to the pressure shown in the suction line gage, and the line *PR* corresponding to the condenser pressure. These lines will normally fall a little above and a little below the corresponding lines on the diagram, since a slight difference in pressure is necessary to open the valves. Should this difference be abnormal, either the pressure gages are off or the valves are sluggish owing to sticking or to excessive valve-spring tension.

The diagram reproduced in Fig. 2 shows good operation for a high-speed compressor. The compression line *CD* falls a little too much below the adiabatic *CG* and indicates a slight leakage through the suction valve or past the piston rings. However, the leakage is very slight and not enough to necessitate overhauling. The card shows the valve action to be good. The suction pressure gage was probably off a little; if not, the suction-valve spring was too stiff. Should the compression line *CD* have come too close to or above the adiabatic *CG*, it would have indicated leaky discharge valves or gaskets, and should it have fallen too near the isothermal *CH* it would have indicated leaky suction valves, gaskets or piston rings. The diagram shows a slightly higher percentage of clearance than the diagram in Fig. 1 from the slow-speed compressor.

Effect of Clearance

Clearance volume is of no particular harm in the ammonia compressor as long as it does not cause excessive heating or produce lubrication difficulties, since the work done on the piston by the expanding of the clearance volume gas practically offsets the work of recompressing it. The clearance volume in modern compressors varies from less than 1 per cent to 6 per cent for different makes of vertical and horizontal compressors. To give a certain capacity at fixed speed and pressures, a compressor having 5 per cent clearance volume will of course have to have a larger cylinder than one having only 2½ per cent clearance volume.

Fig. 3 is a reproduction of a diagram from the head end of a horizontal double-acting high-speed compressor. As is characteristic of this type, the compressor has considerably more clearance than the vertical compressors. Plotting the adiabatic and isothermal curves for the diagram reveals that there is something wrong, since the compression curve falls practically along the isothermal curve. As explained heretofore, this indicates that either the suction valve, valve-cage gaskets or the piston rings are leaking.

Now refer to Fig. 4, which is the crank-end diagram from the same compressor taken at the same time. The compression curve has about the proper relation to the adiabatic and isothermal curves, so the inference is that the trouble on the head end is not due to leaky piston rings. If it were, this trouble would also show up on the crank-end diagram. Therefore the trouble has been narrowed down to leaky suction valves or suction-valve-cage gaskets. After an inspection the trouble in this particular case proved to be a gasket partly blown out between one of the suction-valve cages and its seat in the cylinder head. When the gasket was replaced, a diagram similar to Fig. 4 was obtained. The diagrams show that otherwise the compressor was operating properly.

It is hoped that this brief discussion of interpreting the indicator card from the ammonia compressor will impress upon the plant owner, manager and engineer the vital importance of regularly indicating the compressor and at the same time show how easily the valve and piston action of the compressor can be determined from the card.

How To Apply Tape To Make a Good Insulating Job

By C. M. King

The most common forms of insulating tape are known as friction, which is an adhesive tape of low dielectric strength used largely for the mechanical protection of tapes possessing better insulating qualities, and rubber, which, as the name signifies, contains a large percentage of rubber. Practically all tapes are made in rolls, in widths from ½ to 2 in., and a thickness of cloth is placed between each layer of rubber type, to facilitate unwrapping. Rubber tape is used to insulate joints made in rubber-insulated conductors. During cold weather it may be necessary to warm rubber tape before it is applied, and it is usually applied to a conductor in short lengths, rather than being wound thereon directly from the roll. After the tape is applied, if the heat from the hand is not sufficient to convert the separate layers of rubber into a solid mass,

SHOWS HOW INSULATION SHOULD BE CUT ON A CONDUCTOR SO THAT A GOOD JOB CAN BE DONE ON INSULATING A SPLICE

a blow torch should be used, care being taken to avoid overheating. Treating the rubber with heat prevents the entrance of moisture which would impair the insulating qualities.

Where tape is to be applied to the bare section of an insulated conductor, as at a joint, the conductor insulation should be cut at an angle, as in the figure, in order that the creepage distance shall be increased and to avoid any possibility of the tape, due to shrinkage, leaving a direct opening to the conductor. Even if it is known that the tape possesses insulating qualities as great as an equal thickness of the conductor's insulation, a somewhat greater thickness should be applied, for taping applied by hand cannot be expected to be as effective insulating material as that applied by machinery.

Friction tape can be applied, under sufficient tension, by unwinding directly from the roll, it being necessary to use short lengths only where there is not sufficient space to handle a roll. Where, as in an outlet box, short lengths of tape must be used, lengths that will be convenient for handling and that will avoid unnecessary fouling by sticking should be selected.

The use of friction or rubber tapes should be avoided in places or on apparatus where even small quantities of oil may be encountered, because oil has a destructive effect on these tapes. In the case of friction tape oil

will decompose the adhesive material, causing the tape to loosen and unwrap, and rubber tape will be converted into a jelly-like substance. Hence, if rubber tape is used in oil-insulated transformers, not only will it be destroyed, but the sulphur content of the rubber may be great enough to lower eventually the dielectric strength of the oil.

Tapes made of varnished cambric are extensively used for high-voltage work and, besides possessing excellent insulating qualities, are not affected by mineral oil; hence, they are largely employed in transformer construction. Varnished-cambric tape is made in various widths and thicknesses, cut straight or on the bias, will not absorb moisture and will withstand a fairly high operating temperature. This tape is made in two colors, yellow and black, the black possessing the greater resistance to voltage puncture. The tape can be applied directly from the roll, and when used on cables, it is advisable to apply a coat of quick-drying insulating varnish to each layer of tape.

Cotton and linen tapes are largely employed to protect, as the outer covering, coils of various types and certain classes of electrical conductors, such as those forming switchboard connections. These tapes are usually applied directly from the roll and can be applied rapidly by hand by loosely clamping, through the center, guards against the edges, thereby holding the roll in shape, even when considerable tension is applied. Silk tape is used for the finer classes of work, such as in the manufacture of electrical instruments.

How Taping of Field and Transformer Coils Can Be Facilitated

The taping of field and transformer coils can be greatly facilitated by supporting these coils on two wooden strips attached to a workbench or table. In taping coils with a rectangular opening, the thickness of the tape will be much greater at the inside corners, owing to the difference in radius, as compared with the outside, and this thickness is sometimes reduced by cutting a strip from that part of the tape that will cover the inside corners. Where long lengths of cable are to be taped, the cable is stretched taut at a convenient height above the floor, and the tape generally applied directly from rolls.

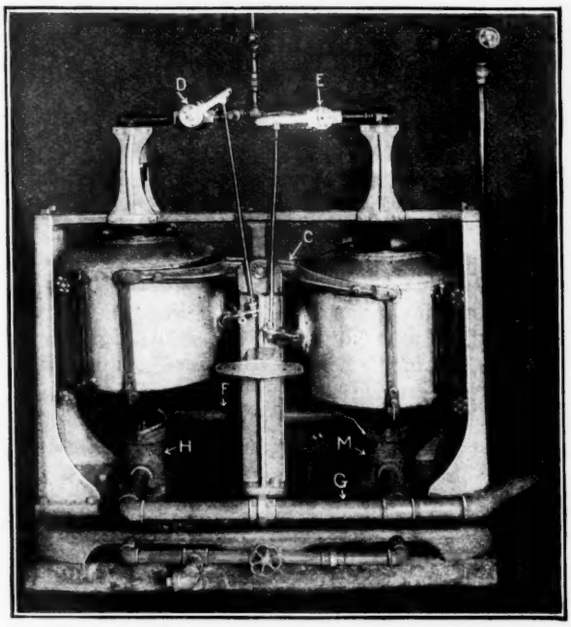
On transformers, generators and similar apparatus, where there may not be sufficient space available to apply the tape directly, even from a small roll, short lengths must be used, and hooks may be employed to wrap the tape if there is not space for the fingers.

Where a narrow, non-adhesive tape forms the protective covering for other tape, the outside end can be made secure by being looped through the last turn and pulled tight. Such forms of tape as linen and cotton can be best secured, however, by sewing the end to the layer beneath. By applying a coat of suitable varnish or insulating paint to the last layer of tape its wearing and binding qualities can be greatly improved. Unless care is taken to select tape that is not too wide, the completed taping will not present a workmanlike appearance. If suitable widths are not at hand, a good many forms of tape can be easily cut or torn to the desired width.

Where considerable taping is to be done on cable or armature coils, a taping machine is practically indispensable, for tape can be applied much more quickly and uniformly by machine than by hand. Such machines consist essentially of a metal ring, guided by idlers, slotted at one point to admit the coil to the inside of the ring. A belt is in contact with the lower half of the ring, which is grooved on its outer circumference. A roll of tape, arranged to be unwound under tension, is attached to the ring, which, when revolved by the belt, carries the tape rapidly around the coil, which is guided by the operator.

Condensation Pump and Receiver Adapted to Sewage Disposal and Other Services

The illustration shows a condensation pump and receiver on which the patent and manufacturing rights were originally granted to John Redmond, New York City, but are now owned by B. F. Bonner, 98 Macon St., Brooklyn, N. Y. A view of the original machine on which the patents were granted was given on page 353 of the March 1, 1921, issue of *Power*. Since that time considerable improvement has been made on the machine, the most important being the reduction of moving parts.



DESIGN OF MACHINE MAKES IT PARTICULARLY ADAPTABLE TO SEWAGE DISPOSAL

The apparatus consists essentially of two chambers, *A* and *B*, carried by the swinging frame *C*, mounted on a ball bearing. A float contained in each chamber and connected through levers and links to the valves *D* and *E* controls the admission of steam or air to the chambers. These valves are of the rotating-plug type (see *Power*, page 802, May 22, 1923).

The condensate or other liquids enter the chambers through the pipe *F* and are discharged again through the connection *G*, the inlet and outlet being through a round opening in a tube that is moved to cover and uncover openings in the cylinders *H* and *M* shown between the chambers and the base.

The principle of operation will be clearly understood by referring to the illustration. The chamber *A* is shown in the filling position, and the condensate is admitted, as previously explained, through the circular plunger connected to the bottom of the chamber. When the water reaches a certain level, pressure is admitted

to the chamber through the action of the float operating the valve *D*. The chamber *A* immediately falls to the lower position, and chamber *B* is automatically raised to the upper or filling position. This action closes the inlet port (chamber *A*) and opens the discharge port and the cycle of operation is repeated.

This apparatus is particularly adaptable to sewage disposal, as there are no check nor gate valves used in its operation around which sewage or other matter can accumulate, and the sewage has a free passage to and from the chamber.

When employed as a condensation pump and receiver, it will return the condensate direct to boilers at a high temperature regardless of pressure.

The apparatus may be used for handling oil and other liquids by using compressed air instead of steam. It will also serve as a water meter, as by attaching a counter it will register the cubic feet of water passing through it, as it cannot reverse from one filling position to another until the chamber is filled.

Governor Adjustments on Hydro-Electric Generating Units

By Ralph Brown*

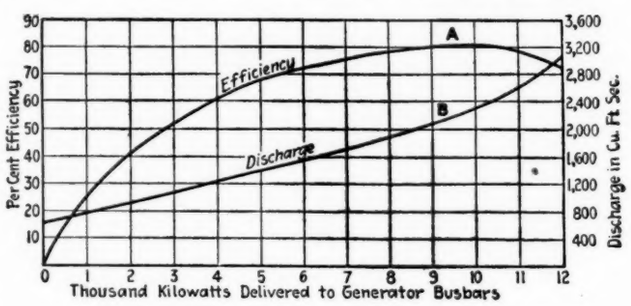
When maintaining the frequency, or governing, the load swings on hydro-electric units may be so great as to require the operation of a unit in addition to the number required for the same average load, but with swings of less magnitude. For example, from the figure, while the maximum load is 12,000 kw., it is probable that a load of 44,000 kw. would be the maximum that could be obtained from four such units without sacrificing speed regulation, for governors cannot be expected to maintain satisfactory speed regulation if the turbine vanes must be moved to the position of maximum opening in response to load changes. If the maximum load demand was 45,000 kw., five units should be operated, and if the average load remained at 36,000 kw., the water consumption would be considerably increased over that required by four units. It is, therefore, difficult to operate units at economical loads when maintaining the frequency of a system subject to relatively large load swings, but an effort should be made to do so, by starting and stopping units as the load increases or decreases.

By plotting an estimated load curve based on accurate data, the number of generating units required at any time of the day can be known except in event of a breakdown of equipment or the occurrence of a sudden storm. It is generally most economical of water, and the best speed regulation is obtained, when the governors of all the units operating in parallel are set to maintain the frequency, but in some plants only one of possibly several governors is set to function under normal conditions at any one time.

The isochronous speed adjustment of some hydraulic governors can be conveniently changed, and where such is the case, it may be advisable, when all the units are nearly wide open, to set all but one or two of the governors at the maximum gate-opening position and to make the ones functioning more sensitive, thereby possibly obtaining better speed regulation.

Where several stations operate in parallel, the frequency should be maintained at the station that can most economically do so, the other plants having allotted to them such blocked loads as may be generated most efficiently. Or, instead of blocking the governors in certain stations, the percentage of isochronous speed regulation of the governors may be increased 2 per cent or 3 per cent, which will result in a fairly constant load being maintained on these stations and probably in better frequency regulation in the event of system disturbance than if the governors were blocked. Since the usual percentages of isochronous speed regulation on governing units are from 2 per cent to 3 per cent if the governors on other units are set for a 5 per cent decrease in speed from no load to full load, this being the usual limit fixed by the construction of most governors, governor action will be sluggish and the gate opening will be changed only in response to considerable variations in speed.

Unless a governor is provided with some form of load-limiting device, it can be blocked only in the positions of no load and full load, this being done by making the speed setting of the governor higher or lower than the normal frequency of the system. For example, if the governor is adjusted to maintain 62 cycles on a 60-cycle system, it is evident that the turbine gates will remain wide open until the frequency of the system exceeds 62 cycles. If a load-limiting device is provided, the gate opening may be set for



LOAD-EFFICIENCY AND DISCHARGE CURVES FOR REACTION TURBINE GENERATING UNIT

any value, and while this opening will not be increased on the occurrence of low speed, an increase in speed will cause the gate opening to decrease. It is obviously an advantage to be able to maintain a constant load of any desired value on a generating unit, and in some cases it may be advisable to add a load-limiting device to existing governors.

Most impulse turbines manufactured during recent years are equipped with automatic needle nozzles, but there are many such prime movers in operation not so equipped, the governor operating a jet deflector or a deflecting nozzle. With such turbines, while any load rejection is necessarily made by decreasing the amount of water impinging on the buckets, the amount of water discharged from the nozzle is not automatically decreased in accordance with rejections of load, hence conditions are unfavorable for the economical use of water. Impulse turbines of this type should preferably be operated at a constant, or blocked load, or if their governors must function, a reduction in the load must be followed by a decrease in the nozzle discharge, to prevent excessive waste of water, while an increase in load must be anticipated, in order that the nozzle discharge will be ample to care for it. Manually changing the nozzle opening in accordance with load demands is obviously an inefficient method, especially where the load is a variable one.

*The Great Western Power Company.

Corrosion by Acid Water

By D. H. Jackson*

It is a common and not altogether erroneous theory to ascribe all corrosion in boilers to acid water. The term "acid water" might, however, convey a different meaning to different engineers, and some discussion of the term should not be out of place. A water that would ordinarily be called "acid" is one that will give an acid reaction with a common chemical indicator such as methyl orange. Natural waters of this type are rare, and the acidity in such cases can usually be attributed to pollution by industrial waste. Such a water would be very corrosive in boilers, owing to the high solution pressure of iron in acid solution.

What Is an "Acid" Water?

The majority of natural waters are alkaline rather than acid, because of dissolved bicarbonate of calcium or other mineral constituents. However, even though these waters are on the alkaline side of neutrality, they all have to a very small degree the principal characteristic of an acid solution; namely, hydrogen ions, which give to the water its power to dissolve iron. An alkaline water is alkaline because it contains free hydroxyl ion, and while all waters contain both hydrogen and hydroxyl ions, they are acid when the hydrogen-ion content is the larger and alkaline when the reverse is true. When the two values are the same, the water is exactly neutral.

Since methyl orange is extensively used by power-plant chemists and engineers for measuring acidity and alkalinity, it is well to emphasize the fact that, while it is very useful in power-plant chemistry, it is poorly adapted for measuring acidity where accurate determinations are necessary in studying corrosion troubles. This is due to the fact that methyl orange changes color slightly on the acid side of neutrality, a fact that is usually overlooked, but is of sufficient importance to be taken into consideration.

The best way of expressing acidity is in terms of hydrogen ions. These ions exist in all waters, including those that are alkaline. At the neutral point the hydrogen-ion concentration is $\frac{1}{10^7}$ grams per liter and the concentration of hydroxyl ions is exactly the same. The product of the two, $\frac{1}{10^{14}}$, remains a constant through the whole range of acidity and alkalinity so that as one increases the other decreases. Methyl orange changes color when the hydrogen-ion concentration is a little less than $\frac{1}{10^4}$, showing that the concentration is nearly 1,000 times greater at this point than at the neutral point. This discrepancy is not so much as might be supposed, owing to the extremely small concentration at the neutral point, but the difference it represents is enough to make considerable difference in the corrosive power of water.

Ordinary Methyl-Orange Test Not Sure

The writer has frequently come in contact with cases where boiler-feed water was considered safely alkaline, whereas it was found to be slightly acid when measured by methods more accurate than the methyl-orange method. In such cases as these it is important to use accurate methods of measuring acidity and alkalinity and, if conditions justify it, to treat the water with an alkaline substance such as soda ash.

*Chemical engineer, Elliott Company.

There are two methods of accurately measuring the acidity of water. The more accurate depends on measuring the electric potential of the solution with hydrogen electrode equipment. The other method is much simpler and, while not quite so accurate gives much more valuable results than the methyl-orange method. Apparatus for this method consists of sealed indicator color standards made from water of different degrees of acidity and alkalinity. With these available, it is only necessary, when testing water, to add a given amount of indicator to the sample and match the color tint with one of the standards.

Iron is soluble in water in proportion to the amount of hydrogen ions present. However, the attack of hydrogen ions on iron does not proceed steadily unless conditions are right. When iron goes into solution, the hydrogen ions in the water are changed to free hydrogen gas, which gives up its electric charge to the iron with the result that the iron becomes polarized, which tends to prevent further action. The solution or corrosion of iron in the average neutral or slightly alkaline natural water is very small and would automatically stop were it not for dissolved oxygen in the water. Unfortunately, all waters contain small amounts of free dissolved oxygen gas from the atmosphere unless the water is specially treated to remove this dissolved gas.

Oxygen Forms One Link in the Chain

This dissolved oxygen always enters aggressively into the process of corrosion of iron and steel. It unites with the hydrogen liberated by the iron-solution process and prevents the polarization of the iron. It also reacts with the dissolved iron and precipitates it as iron oxide or rust. As the iron is thrown out of solution, more hydrogen ions are simultaneously liberated and the process goes on in cycles, depending on the amount of dissolved oxygen in the water and to a lesser degree on whether the water is acid, neutral or alkaline.

Nature has provided a partial preventive for corrosion by carrying in solution dissolved minerals such as carbonates and sulphates. These settle out on the interior surface of piping and boilers and form a protective coating, which is usually very effective in preventing corrosion. However, this natural remedy is such a detriment to heat transfer that its value from the viewpoint of corrosion prevention in boilers is considerably more than offset by the heat loss it causes. The best and safest method, therefore, of preventing corrosion, is to remove the dissolved oxygen from the water. Apparatus for this purpose is being extensively installed in power plants and hot-water systems.

Distilled water from condensate returns or other sources is more corrosive than natural water, because it contains no dissolved minerals to give an alkaline reaction and reduce the hydrogen-ion content. Distilled water also has the capacity for dissolving more oxygen from the air than natural water. A further disadvantage is a slight acid reaction, due to carbon dioxide from the atmosphere. In natural water the carbon dioxide from the atmosphere is usually neutralized by mineral constituents, whereas in distilled water it forms small amounts of carbonic acid, which increases the iron solution pressure. However, distilled water when treated by modern apparatus to remove dissolved oxygen and other gases, including carbon dioxide, furnishes an ideal water supply, and systems of this kind are growing more and more in favor.

Mammoth Plate-Valve Air Compressor

One of the largest air compressors on record using plate valves, as installed at the plant of the Hollinger Consolidated Gold Mines, Ltd., Timmins, Ont., Canada, is shown in Fig. 1. Supplying compressed air to the mines at 105 lb. gage pressure is the service. The compressor is of the Nordberg horizontal two-stage heavy-duty constant-capacity type, 50 and 29½ by 36 in.,

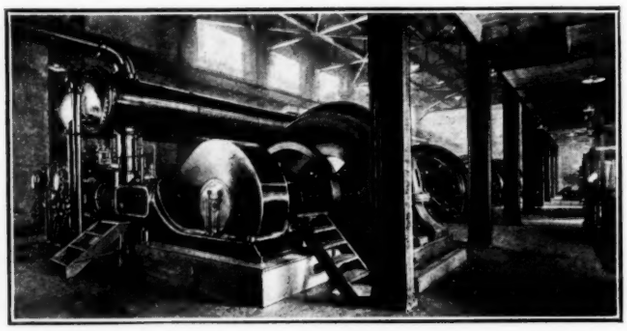


FIG. 1—LARGE PLATE-VALVE COMPRESSOR SERVING HOLLINGER MINES

with cranks coupled at right angles. It is directly connected to and driven by a self-starting synchronous motor taking three-phase 25-cycle current at 11,000 volts and delivering 1,565 hp. at full load. The motor is of the revolving-field engine type and has a WR^2 of 400,000 lb.-ft.^{2}, the flywheel effect being sufficient to obviate the necessity of a flywheel. At a running speed of 125 r.p.m. the compressor has a piston speed of 750 ft. per min. and a volumetric efficiency approximating 92 per cent. The shipping weight was estimated at 175,000 lb. for the compressor and 83,000 for the motor.

The motor is on the main crankshaft mounted between the frames of the compressor and operates the

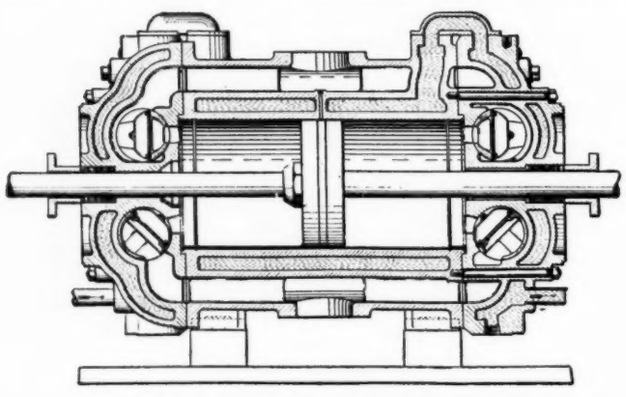


FIG. 2—SECTION THROUGH COMPRESSOR CYLINDER

pistons by means of cranks, connecting rods and crossheads, tailrods being used on all cylinders. Each cylinder is water-jacketed on the barrel and heads, the jacket connections between cylinder and head being outside to prevent leakage of water into the air spaces.

One of the interesting features of the machine is the valves, which are of the automatic spring type. Each end of the cylinder has a number of these valves arranged in multiple on a removable seat, so that the whole set may be removed as a unit. The valve cage is cylindrical and is mounted similar to a Corliss valve, as shown in Fig. 2. This feature permits the conversion of the old type compressors having positively operated inlet and outlet valves, by equipping them with new automatic valves.

In the machine under discussion the seat for the inlet valve in the low-pressure cylinder is V-shaped, there being a series of 57 valves with springs on each leg, making a total of 114 valves. The low-pressure discharge valve has a series of 132 valves and springs. Each of the high-pressure inlet and discharge valves is equipped with single-deck valves, 41 in number.

By means of an unloading device consisting of a regulator having control of oil cataract cylinders or pressure pots, the compressor may be operated at full capacity, one-half or no load. To operate at 50 per

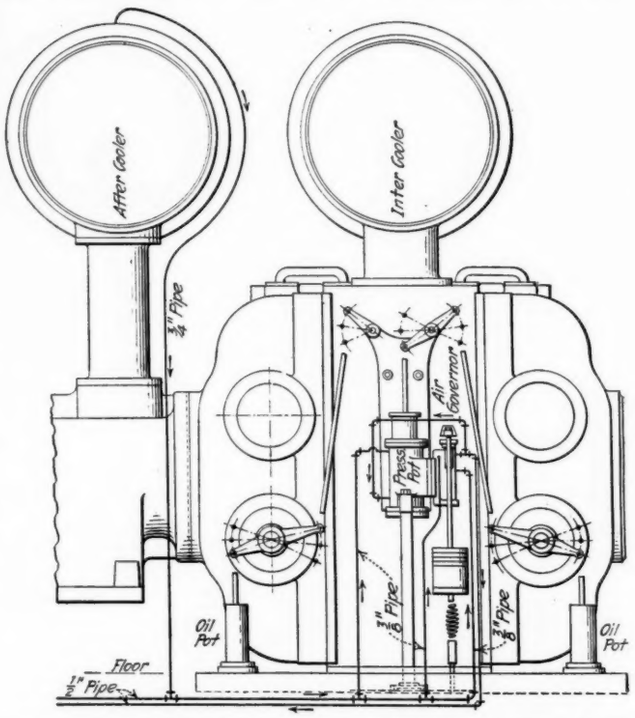


FIG. 3—PRESSURE POT ON LOW-PRESSURE SIDE OPERATING HEAD-END HIGH- AND LOW-PRESSURE SUCTION VALVES

cent capacity, the pressure pots turn the inlet valves at one end of both the high- and low-pressure cylinders, so that there is free admission and discharge and consequently no work done. The operation will be plain from Fig. 3, which shows the pressure pot and its connections to the valves of the low-pressure cylinder. To eliminate air delivery entirely, the inlet valves at the other ends of the cylinders are turned in the same way, this control being effected automatically when the pressure reaches predetermined limits.

To save power and incidentally to hold temperatures within reasonable limits, the compressor is equipped with an intercooler and an aftercooler, both being of the horizontal tubular type located above the cylinders. Each cooler has 2,140 sq.ft. of effective surface and is provided with baffle plates for both air and water, so that both mediums are caused to circulate through the cooler several times. With water entering at 60 deg. F., the guarantee is to cool the air to within 12 deg. F. of this temperature.

Lubrication of the compressor is effected by an automatic oil-circulating and filtering system.

Reminiscences of a Veteran Mechanical Engineer—VIII

An Account of the Establishment of the Otis Elevator Works and Some Indicator Work Done There by the Author

By W. H. ODELL

This is the last installment of this series of reminiscences, but there have been letters, discussing subjects contained in these articles, from F. W. Dean and N. G. Herreshoff, which will be published in an early issue.

AMONG the Simon pure American industries of our country none probably has done more to put Yonkers, N. Y., on the map than the Otis Elevator Co. There are many other notable manufacturing establishments in this terraced city whose goods go broadcast over the world, but although the users of such goods as sugar, carpets, etc., know nothing about who made them, in every elevator made by the Otis company the firm name and the place of manufacture are seen by the hundreds of thousands who use them daily, and in this way the name will endure, and it is to Charles R. Otis, the only surviving member of the original Otis family, that I am indebted for much of the early history of this widely known establishment.

After much inquiry Mr. Otis was found in his retreat, "way down east," and I quote as follows from his kind letter in answer to my inquiry:

Replying to yours of March 29, would say that I am somewhat at a loss to know just what data you wish.

Benjamin Newhouse, of New York, was one of the proprietors of a company that started a furniture manufacturing business in what was called the old Bedstead Factory at the foot of Vark Street, Yonkers, on the site of the present Federal Sugar Refinery. Mr. Newhouse also had a furniture factory and store in New York City.

My father was employed as master mechanic to take charge of, construct and install machinery in the Yonkers factory. This was about the year 1852.

Among other things, my father, Elisha G. Otis, originated and introduced an elevator that was supplied with safety appliances of his own invention, that would prevent the elevator from falling in case of the parting of the lifting rope. On having these safety appliances brought to his attention, Mr. Newhouse appreciated their advantages and ordered one or more machines that were equipped with them, for his furniture factory and store in New York.

These machines came to the attention of Messrs. Searls and Williams, neighboring manufacturers, who also ordered one or more machines for their own factory. Other concerns did likewise.

After completing and installing the machinery for the manufacture of furniture in the Bedstead Factory, my father gave more time to the construction of elevators. The first machines that he introduced attracted attention especially to his safety appliances which specifically characterized them. A portion of one of the buildings of the Bedstead Factory in Yonkers was used by my father for the construction of these machines. This was the beginning of the elevator business. My father died in 1861.

As the business grew and required larger quarters, his two sons, Charles R. and Norton P. Otis, who succeeded him in the business, purchased the property at the corner of Wells and Woodworth Avenues and Atherton Street and erected buildings as they were needed. From this the present large Otis Elevator concern has been developed.

Charles R. and his brother Norton P. Otis were good sports in their young manhood and fellow members of the Yonkers Corinthian Yacht Club, of which the writer was chairman of the house committee during the first few years of its organization; and they nobly backed

CHARLES ROLLINS OTIS

the house committee in their efforts to foster a clean club.

We did not purpose to make it an annex to any Y. M. C. A., but we did decide that no entertainment should be staged at the clubhouse except such as we could take our wives and children to, and I firmly believe this decision did much to establish the standing of this club with neighboring clubs, until the advent of the motor boat and the automobile took the wind out of our sails for a time. But I may say here that I firmly believe this sport will in time come into its own again, for there is a subtle something in the sea that appeals to red-blooded men, and surely there is nothing in creation that shows the might and majesty of the great engineer of the universe like the ocean in a storm. Any saphead can run a motorboat or car, but it takes brains to sail a boat and win the race. If anyone not well informed doubts this statement, let him ask the

world-famed builder, Nat Herreshoff, to whom I have referred in a former article, or others like that thorough yachtsman and gentleman, David Moffat Myers—they know.

However, this is going far afield, and to return to my subject I will mention my first service to the Otis company. When the first building was erected on the site of the present large works at Yonkers, it was equipped with a small Harris-Corliss engine. I cannot remember the size, but I think it was about 50-hp. Its rated speed was supposed to be 85 r.p.m., but as a sample of engineering efficiency of that day it was decided, in order to get the right speed for the lineshafting, to reduce the speed to 55 r.p.m. This did not

NORTON PRENTISS OTIS

prove a success, and the engineer monkeyed with the valves until about all the work was done in the crank end of the cylinder, and the result was a decided slowing up when passing the center, which was very noticeable in the quick-running machinery such as the circular saws, emery wheels, etc.

About that time (I think it was 1869) I had begun to make a noise with my steam-engine indicator, setting valves, measuring power, etc. Prof. F. R. Hutton in the foreword to his history on the foundation of the A.S.M.E. (1915) places said noise as some ten years later, but I was well on the job in 1869, and as the Otis company was among the first of my clients, I am inclined to think my date is right. However, the date does not matter so much. Of course it would be well to have it historically correct, but the gist of it is, I set the valves properly, put a larger pulley on the lineshaft and changed the governor back to the original speed, and all was well

The Otis brothers were neither of them very keen on yacht racing, but were splendid citizens, and Yonkers doubtless owes much to their enterprising spirit. Norton Otis was sent to the State Legislature, but politics proved too dirty a business for one of his ideals, and he would not accept a second term, but the purses of both brothers were open to every worthy object, and I know of several whose start in life was due to them and their noble wives.

Another sample of early engineering came to my notice in Yonkers at about the time of which I write, and though it had nothing to do with the Otis plant, it may be of interest here.

One day I chanced to meet in a barber shop a sugar manufacturer who was one of the characters of the city. He operated a small beam engine of 14-in. diameter of cylinder, 30-in. stroke making an average of 73 r.p.m. in operation twenty-four hours a day. In answer to his inquiry, "What are you doing now, Billy?" I told him about the efficiency of the indicator, but he would not believe it and gave me a look that said as plain as words could say it, "The Lord is said to love a cheerful liar," and when I suggested the use of this instrument I was met by the stock argument of many plant owners of that day, such as "Why, I had that engine well overhauled last spring," and "I've got a good engineer"; "I guess I got to burn coal to make steam," and "I guess I know more about my engine myself than anyone can tell me by making a few marks with a pencil on a piece of paper," etc. But he was prevailed upon to have a test made and it was found that both valves and piston were leaking terribly. The piston was blowing through because of the follow-bolts striking the bottom before the fallover was properly in place. There was a counter-pressure of 20 lb. on the exhaust, caused by a weight placed on the exhaust after it passed through a tank, and from this tank a part of the exhaust was carried some 80 ft. through ¾-in. pipe to a small tank of liquid and used only two hours out of the twenty-four hours' run. This I think was the most awful case of mismanagement I have ever met in my many years of practice, but after scraping the valves, repairing piston, relieving the exhaust by using it to heat the feed water, etc., the coal consumption was cut about one ton per day of twenty-four hours, to the surprise of the owner.

In connection with this case, may I say that along in the early seventies I was approached by the Otis people with the offer of an appointment as inspector of their works; but the "science of steam" had got in my blood and I had to refuse this offer. Sitting here in my old age, I often wonder if I did the right thing in refusing to get under a corporation umbrella, and I also wonder if there is any lesson in this for the young engineer of today. I frequently advise promising young engineers to get in business for themselves—to be their own bosses. Am I right or wrong in this? Had I gone under a corporation umbrella, I would now probably be sitting under my own vine and fig tree, in peace, but would I have lived the life of service that has been mine? Would I have invented and patented so many useful devices to be stolen by patent pirates who are now reaping the rewards of my inventions? Often I exhausted my bank account in fighting, in the courts, for my rights. This is a wonderfully big question, and I wish I might solve it for the young engineer, but on the whole I guess I was right in my choice. To use one of the late Theodore Roosevelt's expressions, I have had a bully good time, have made a host of worthwhile friends, and think if the past could be recalled I would do the same thing over again, except that I would not patent my inventions unless I felt assured I had sufficient means to sustain my right in the courts.

EDITORIALS

F. R. LOW, EDITOR

Clearing the Way

PENDING conflicts of federal and state authority as to water-power development on navigable and boundary streams appear to have been largely removed as a result of the recent conference between the Federal Power Commission and representatives of the State of New York. A frank exchange of views between the two bodies revealed that they were not very far apart after all. For instance, the conference developed that the Commission has not issued and does not intend to issue a license to anyone that has not first secured authority from the state, also that states and municipalities shall at all times be given preference over private interests provided the plans filed are satisfactory and show adequacy of development.

Before the creation of the Federal Power Commission dual consent of the states and Congress was necessary before any development could be undertaken. This usually involved long and useless debates on the floor of Congress. The Water Power Act merely delegates this federal authority to the Commission, provides machinery for the investigation of all applications, prescribes a uniform system of accounting and lays down certain other procedures. In no sense does it attempt to usurp the rights of any states.

The Federal Power Commission has been accused of receding from its position on many points as a result of the conference. A close study of the minutes, however, indicates that what might appear as concessions are really liberal interpretations of the act. It evidently is the policy of the Commission that more can be accomplished through a spirit of conciliation and co-operation than a too strict insistence on the letter of the act. In this way issues have been avoided which, if carried to the courts, might have seriously impeded water-power development.

Does High CO_2 Mean High Efficiency?

THE constant emphasis on the importance of high CO_2 may lead some engineers to wonder whether other equally important factors of efficiency are not being neglected. The question arises as to whether high CO_2 necessarily implies high boiler efficiency. The answer is that under ordinary practical conditions it is almost always accompanied by high efficiency, although one can think of a number of ways in which a boiler could combine high CO_2 with low efficiency.

The principal boiler and furnace losses are due to sensible heat in flue gas, incomplete combustion, combustible in the ash and radiation. Running through this list, it is recalled that the sensible-heat loss depends on two factors, the percentage of CO_2 and the flue-gas temperature. As far as the mathematical expression for the sensible-heat loss is concerned, one element is as important as the other. In practice the flue temperature needs much less attention, for the simple reason that if the CO_2 is right and the boiler reasonably clean, the flue temperature will practically take care of itself, no large improvement being possible without radical changes in design or operating conditions. For a given rate of driving, the higher the CO_2 the lower is the flue temperature. Therefore for any reasonable boiler design, high CO_2 means small loss in sensible heat. Incomplete combustion does not as a rule represent a loss large in comparison with the sensible-heat loss. At the same time it should be carefully watched, particularly when the CO_2 is exceptionally high. There remain the losses due to combustible in the ash and to radiation. Under ordinary conditions these losses are well worth careful attention, but they cannot be ranked in importance with the sensible-heat loss.

Nevertheless there are several possible conditions that could lead to low efficiency in spite of high CO_2. Among these are high flue temperature due to an extremely dirty boiler or to insufficient heating surface, the presence of a large amount of CO, an extremely high percentage of combustible in the ash and a large radiation loss due possibly to excessive radiating surface per unit of developed capacity. These possibilities prevent high CO_2 from being taken as absolute proof of high efficiency. At the same time boiler plants that contain the skill to maintain high CO_2 will rarely be so badly operated in these other respects as to exhibit a poor over-all efficiency.

Cost of a Kilowatt-Hour

THE cost of power, roughly speaking, is frequently visualized as depending upon: (1) Investment and fixed charges, (2) load factor, (3) efficiency, (4) supervision, material and labor. The last group, including cost of fuel, may vary considerably.

Two other quantities, however, are highly important as brought out in a recent paper by Colonel Junkersfeld. They are obsolescence and the generator capacity factor, which it chiefly affects. The latter, particularly, may change the cost of a kilowatt-hour fifty per cent or more from that represented by the first four quantities.

The increase of fuel cost accompanied by the development of more efficient apparatus tends to hasten the time when a prime mover or other unit may be economically superseded by a later one of greater efficiency. Steam engines installed between 1902 and 1906 in central stations became obsolete sooner than steam turbines installed during the same period. In this case failure to make use of innovations which resulted in purchasing the older type steam engine made their obsolescence more rapid. However, while obsolescence may appear as a growing reason for increasing the cost of investment per kilowatt-hour, it also is the result of a saving produced otherwise and is not so vital a factor as that of the generator capacity, representing the ratio of actual output to possible output.

The experience of a number of companies, including eighteen power houses and 113 steam turbines, aggre-

gating over two million kilowatt rating, indicates that for a two-year period, the average generator output factors of two companies were twenty-two and forty-six per cent.

The extra fixed charges per kilowatt for one of these two companies would therefore approximately double that of the other. The apparatus involved in causing such divergence of cost included auxiliaries and accessories of the turbo-generator unit, such as condenser, piping, electrical switches and equipment allied to the generator.

The lowest capacity factors were attained by turbine sets nine and ten years old, while the highest applied to those installed up to three years. This indicates the results of obsolescense in decreasing the capacity factor and increasing the cost per kilowatt. The tendency is to operate the latter more economical units in preference to those of older and less economical design.

Obsolescence is a problem of both economical and practical aspects. Rising fuel costs stimulate better economy as well as the deleterious effect of rapidly changing designs and more severe steam conditions. The latter circumstances put the prime mover at a mechanical disadvantage, tending to reduce the effectiveness until improvements can be worked out and applied. Here again, is an inducement to arrange for greater capacity in order to forestall emergency conditions. Therefore, there is less necessity of operating the older units under normal circumstances.

Old machinery in some respects is well suited for stand-by or emergency service, owing to the fact that there has been ample time to observe and correct operating faults. Continuity of service becomes increasingly valuable and stand-by equipment as a consequence should have some recognition as a necessary investment resulting from rising costs of both fuel and power interruptions.

Preheated Air and Boiler Efficiency

THE effect of preheated air on boiler efficiency deserves particular attention at the present time. There are some misconceptions prevalent that it is well to clear up, and certain of these will be now discussed.

It is assumed in analyzing the heat distribution resulting from the combustion of a pound of coal in a furnace, that a portion of this pound is used to heat the flue gases through a temperature range equivalent to the difference between the temperature of the air entering the furnace and the temperature of the gases leaving the boiler. If the air is preheated, this temperature range is lessened by the amount of preheating and the heat equivalent to this range of preheating will be available to produce steam in the boiler.

Some have assumed that the whole of this regained heat does not go toward increasing boiler efficiency. In other words, they assume that only a portion of this reclaimed heat is transferred to the boiler water and that this portion is the same percentage as the boiler efficiency without air preheating. For example, if the boiler efficiency without preheating is seventy-five per cent and if six per cent of the heat in the fuel can be recovered in an air preheater, then it is assumed that the improvement in boiler efficiency with preheated air would be seventy-five per cent of six per cent, or four and one-half per cent, making the boiler efficiency with preheated air seventy-nine and one-half per cent.

A moment's consideration will indicate that this method is not correct. When air is not preheated, the heat required to raise the flue gases through the temperature range equivalent to the difference between room temperature and the temperature of the water in the boiler tubes, is never available for transferring heat into the boiler and for producing steam. The remaining heat in the pound of coal must therefore have a relatively higher efficiency of heat transfer than is indicated by the conventional boiler efficiency which, as is well known, is calculated on the total heat per pound.

Now all heat added by the preheated air is made available above the temperature of the boiler water, and its rate of transfer should therefore be in excess of the conventional boiler efficiency and therefore in the preceding example more than four and one-half per cent should be added to the boiler efficiency.

There is still another consideration. Preheated air will tend to raise furnace temperatures. Any increase in furnace temperature greatly increases the rate of radiant-heat transfer to all boiler surfaces exposed to the direct rays of the fire. This is evident when one considers that the rate of radiant-heat transfer varies as the difference of the fourth powers of furnace temperature and boiler temperature and that small increases in furnace temperature make large increase in the fourth power of this temperature. If sufficient boiler surface is exposed, a much greater portion of the heat from the coal will be absorbed as radiant heat with preheated air than was the case without preheating. Under such conditions less heat remains to be absorbed by convection, and the flue-gas temperatures are lowered. In other words, the total heat transfer will be improved and the boiler efficiency will be further increased by the use of preheated air.

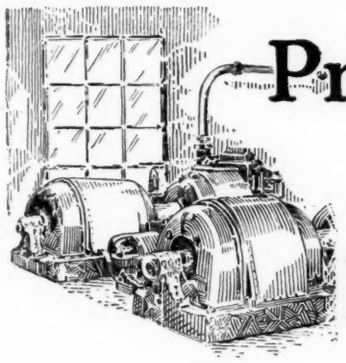
It is difficult to state in mathematical terms the combined effect of these two influences resulting from the use of preheated air. Tests of recent data seem to indicate that their combined result raises the conventional boiler efficiency by an amount equivalent to the percentage of the heat in the coal reclaimed in the preheated air. In the preceding example this recovery of six per cent would increase the boiler efficiency to eighty-one per cent.

These considerations are factors of considerable importance in evaluating air preheaters in power plants.

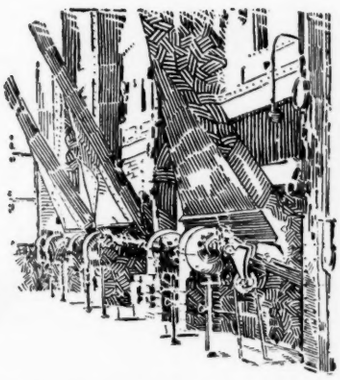
Few engineers upon taking charge of plants will find instruction books pertaining to the care and handling of the equipment. These are usually furnished by the manufacturers at the time of installation, but early operators often have the habit of appropriating such information for their personal use. A few more "do's" and "don'ts" stamped on plates permanently attached to the apparatus would relieve the situation.

Last winter, when the conference of bituminous operators and miners came to a deadlock and another strike threatened, the Federal Coal Commission found it necessary to "wield the big stick" and an agreement was effected. It may become necessary to repeat the performance with the anthracite operators and miners.

The work of the practical man, usually overshadowed in importance by that of the designer, may nevertheless compare favorably with the latter's in the saving of dollars, since continuity of power service has become so increasingly important.



Practical Ideas *from* Practical Men



Miscellaneous Meditations

Whenever any change is made in the adjustment of an engine or other part of a steam plant, it ought to be tested before it is put into operation. If there is lost motion in the crankpin bearing, it is not a good idea to take it up about fifteen minutes before seven o'clock, when the full load is to go on at the regular time. The crankpin might heat and make it necessary to shut down and cool it off. It is much better to adjust the pin the night before and run it a few minutes by way of trial. It is better still to take it up early in the morning, then give it a trial before it is wanted at the regular time.

An assistant engineer or a fireman may wipe up all parts of an engine that are readily seen, but leave other parts that are not so prominent. Observing visitors are quick to notice such conditions and to rate the plant accordingly. Sometimes the engineer begins to open a valve that looks very bright, but when he has given the wheel one-half turn, the bottom part of the stem comes to the top, and as he continues to turn it, first the bright part shows up, and then the dull part follows, when it should be bright all the way around. A man who is thorough in his work will make it all bright.

Sometimes the stuffing box of a pump needs packing, and there are two ways of doing the job. One is to screw the gland down as far as it will go and perhaps put in one new ring of packing. The other is to remove all the old packing and fill it entirely with new. By looking at the outside of the gland, nobody can tell which plan was adopted, but the latter insures a good rod for a long time. The former results in a scored rod and much water leaking out on the floor.

An engineer may send an assistant to pack a pump, but unless he stands and watches the operation, he cannot know the true condition of affairs until the damage has been done, and then it is too late. The same results may be secured when packing a valve stem. Neither is an agreeable job when the parts are hot, but the man who persists in doing thorough work along this line, will be recognized sooner or later.

Every engineer and fireman has a perfect right to have, and to express, his opinion concerning oil, packing and other supplies furnished him for operating the plant, but it makes quite a difference where the opinions are expressed.

Suppose that the purchasing agent buys supplies without consulting the engineer. If they are not suitable for the service required, it is useless to condemn them to the mill hands or to persons around the mill. The purchasing agent should be informed of the exact condition of affairs and be asked to reform his practice. If he will not do this, it remains for the engineer to make the best of what he can get, but an intelligent engineer should be considered capable of selecting the supplies that he is to use.

Occasionally, we find an engineer who has discovered some points concerning steam engineering which he is convinced are not generally known to members of the craft. He makes strenuous efforts to guard his secrets, but if he should associate with engineers and compare notes concerning the business, he would find that there are many things that are not dreamed of in his philosophy. General discussion of engineering subjects would bring out so many new points that he would become lost in a forest of new ideas, which form a pleasing addition to the stock in trade of almost every ordinary engineer. One of the best-posted and thoroughly self-educated engineers that I have ever known, always took great pleasure in educating young engineers whenever they would listen to him, and many of them owed much of their education to his assistance.

On the other hand, many of the engineers who decline to tell their secrets, have but few to tell when the matter is thoroughly investigated. The greatest trouble we have in reaching such men, is due to the fact that they are not looking for new subjects, hence seldom read technical papers.

W. H. WAKEMAN.

New Haven, Conn.

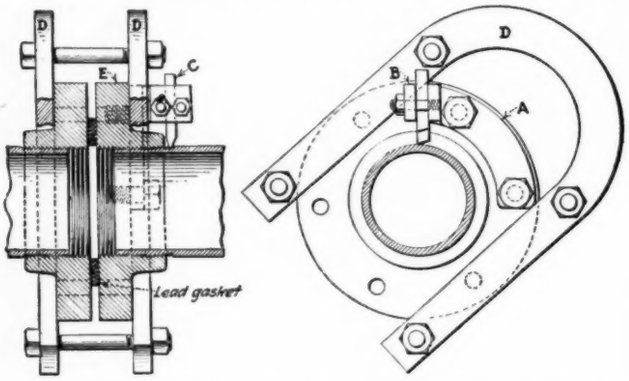
Lengthening Threads on Pipe While in Use

During the latter part of the winter one of the 4-in. main leads carrying the steam at about 15 lb. pressure to a customer's warehouse a block away developed a leak at the flanged coupling where it passed out from the boiler room down into the ground to the buried line. On examination it was found that but a few threads had been engaged between the pipe and the flange when the line was assembled and the continuous leaking was fast making a larger opening around the threads. Adhesive cements were applied, but the two parts were so loose that this material would crack off and there was danger that the connection would give way unless permanently repaired. It was dangerous during the cold weather to disassemble the line, so to make the repair the following method was used:

More threads were needed on the pipe before the coupling could be screwed on farther. Two of the connecting bolts were removed and a forged $\frac{1}{2}$x1$\frac{1}{2}$ cross-section bracket *A* was shaped to the outer face of the flange, and two holes to match those in the flange were drilled. The two holes in the flange were tapped and the bracket was attached to the flange with capscrews.

One end of the bracket was bent at a right angle to form a rest for a diamond-pointed threading cutter. The point of this cutter was set in the last thread cut on the pipe and a strap *B* used to clamp it in position.

Two U-shaped forgings were then made, as shown by *D*, with a spread a little wider than the diameter of the shoulder of the flange, and as the bolts of the coupling were removed one at a time capscrews were placed in the holes drilled in the U-shaped irons. The



TOOL CUT NEW THREADS ON PIPE AS FLANGE WAS TURNED WITH WRENCH

capscrews were tapped in one of the irons to hold the two more rigidly together. As all the bolts were removed from the coupling, the four in the U-irons clamped the flanges together. Chain pipe wrenches were then placed on the flange *E* and this was screwed on the pipe with the cutter *C* forming a new thread as the pipe entered the flange. The bolts in the U-irons were kept just tight enough to prevent too much steam from escaping, but allowed the irons to slip around on the stationary half of the flange. Oil, was applied to this surface between the U-iron and the flange. A lead gasket between the flanges was not damaged, and as the bolts were replaced and drawn up, a perfectly tight joint was made. G. G. McVICKER.

North Bend, Neb.

Increasing the Efficiency of the Operating Department

I shall not attempt to estimate the value of a highly efficient operating department, as men better qualified have already written volumes on that subject. Nor do I claim that by following the few suggestions here given, a badly demoralized system will emerge overnight as a highly efficient one. However, if the suggestions presented are applied in a conscientious manner by those in authority to do so, and are accepted in a like manner by the employee, a great deal may be accomplished toward gaining a better understanding between employer and employee.

Care must be taken that only cool, concentrated men, possessing self-confidence, who thoroughly understand their "business," are placed in the operating department of the various power plants and substations of the system. It may be found advantageous to take men from a station of less importance and place them in another of greater importance or vice versa.

Facilities should be provided for an educational program and the men encouraged to take advantage of it.

In each station there should be one operator responsible for the actions of the men in his charge. He should be appointed annually or semi-annually by the result of a competitive examination, the entire operating staff of the station participating.

The manner of conducting this examination I will leave to the judgment of those empowered to do so, but I suggest that the past record previous to the last examination be taken account of in marking an entrant's paper.

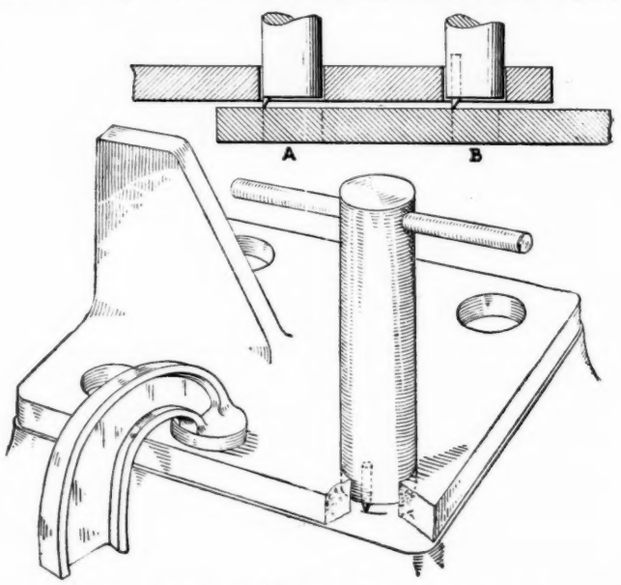
It is not necessary to go into great detail to show what advantages may be gained if these suggestions are followed, for if the material is of the right quality both employer and employee should reap much from the effort expended. P. J. KOLODZIEJ.

New Rochelle, N. Y.

Marker for Locating Adjacent Holes

Where bolt holes are located in any piece of work, as a bracket would be located on an engine casting, they are usually placed by using the bracket as a templet for marking the position of the holes. Usually, a scriber is used for this work, and with the bracket clamped down the holes are circumscribed. As the drill for tapping is smaller than the outside of the tap the scribed line is only an approximate centering circle.

A tool that will scribe a circle corresponding to the diameter of the hole is shown at *A* in the illustration, and a marker with the scribing point inside the edge of the hole for locating the drill diameter concentric with the hole in the bracket is shown at *B*. In the tool shown a circular mandrel, with a turning handle and a seperate steel point is used. The point can be made a part



THE MARKING POINT CAN BE MADE PART OF THE MANDREL OR A SEPARATE TOOL AS DESIRED

of the mandrel if desired. This tool can be used with equal advantage in locating rivet or bolt holes in structural plates, where one set of holes have been punched and these are used to mark the adjacent holes from. The marker for this instance should be made with the scribing point cut to the edge of the marking tool, as shown at *A*. G. A. LUERS.

Washington, D. C.

Comments from Readers

Is Too Much Expected of the Engineer?

I was interested in J. G. Waters' article in the July 3 issue, "Is Too Much Expected of the Operating Engineer?" It brings up a question that is vitally important. How much work should the engineer do and should he receive any extra pay for extra work and if so, how much? I believe a satisfactory settlement of this question is a long way off, but a better understanding with the manager could be obtained by a little effort on the engineer's part.

I am going to disappoint Mr. Waters by saying that in my opinion he should not receive a cent extra for any work he does in his department. The head of any department is responsible for its efficient service and cost.

It has been my observation that the trouble with most engineers, when accepting a position, is that they are so eager to obtain the job that they often agree to do more than they ever intend to do, or after awhile, falling into a rut, they let things slide until extensive repairs are necessary and then feel entitled to extra pay for doing it. When an engineer sells his services to a manager he should have it definitely understood who has any authority over him and from whom he shall take orders; that every man in his department is under his orders only and that no meddling by anyone else will be tolerated; that the pay will be so much per week with two weeks vacation a year with pay, to be taken when, in the judgment of the engineer, he can best be spared; that all repairs shall be done by workmen hired by and under the supervision of the engineer; and that he (the engineer) is responsible for the continuous maximum output of his department at the lowest possible cost and as long as this condition is lived up to the pay shall remain the same whether the engineer works one hour or one hundred a week. Of course this applies to chief engineers. All other men should work for so much an hour, a stated number of hours per week and overtime for all extra work.

I have already spoken of the engineer selling his services to the manager. This may sound far-fetched to some, but that is just what happens. Every successful engineer must be a good salesman, and the better the salesman the more successful the engineer. Unconsciously, perhaps, the engineer is continually selling his employer something. It may be a new boiler that will save so many thousand dollars a year by burning less coal, a new engine that will make a big saving by using the exhaust, meters to show where and how much power or steam other departments are using, recording and integrating instruments to stop leaks and wasteful methods, or it may be the engineer's own services.

Labor is a commodity as much as anything else. When a manager is in the market for labor, he uses the same tactics in supplying his needs as he would if he was buying a carload of leather; that is, he tries to get all he can for his money. Therefore it is up to the engineer to convince the manager that his services are the best he can buy and that they are worth something Go after him the way you would to sell some new equipment, show him why he needs your services, why he can save money by hiring you, and make him believe that you are really doing him a favor by taking his job, and then the question of salary can be easily taken care of. Now you have got to keep the manager sold on your services if you expect a raise. Keep continually showing records where improvements have been made, where a saving has justified a previous expenditure; keep continually making suggestions where conditions could be improved and the manager will unconsciously follow your advice, and a raise in pay is bound to follow. Don't be afraid to take any blame that is due you, admit your faults and the manager will forgive you because any man that does anything is bound to make mistakes once in awhile. When making a recommendation, do so with some enthusiasm or it will fall on deaf ears.

I believe that it would be profitable for all the manufacturers of power-plant equipment to establish a school of salesmanship for engineers, because it is the engineer who must sell the managers first.

Now in my opinion it is up to Mr. Waters to sell his services to his manager over again and show him why a chief engineer has enough to do besides replacing boiler tubes except in an emergency and that all work and no play never made an efficient chief.

Rockland, Mass. BURTON W. WHEELER.

Explosion in Receiver at Low Pressure when Compressor Is Started

Referring to the article in the June 26 issue on the double air tank explosion, I had a somewhat similar although not so disastrous explosion some months ago.

The air pressure on the receiver is normally carried around 100 lb., the safety valve being set to relieve at 103 lb. The day of the explosion the compressor had been running continuously for 8 hours and was stopped as usual at 5 p.m. As the low-pressure crank required adjusting, this was done immediately after shutting down and took about half an hour. By this time the pressure on the receiver was about 30 pounds.

To make sure the adjustment was all right, I decided to try the compressor before going home. I had no sooner closed the switch on the motor circuit than the explosion occurred. The safety valve was blown off the tank, and volumes of smoke and flame shot out.

I extinguished the flame and flooded the receiver. As a new safety valve was available, I installed it on the tank and started the compressor and blew the water out through the drain; considerable carbon was washed out of the receiver with the water. I then put a hydrostatic test of 180 lb. on the receiver and found that it was not damaged to any extent other than the blowing off of the safety valve.

I had always made a practice of blowing out the receiver at noon and at 5 p.m. each day if no air was being used at the time, but the day of the explosion this

was not done, as I intended doing it after making the repairs to the compressor. Since then, however, I have taken additional precaution, and once a week a lye solution is pumped through the line to the receiver.

Now, as to the cause of the explosion, I concluded that some carbon was blown through the pipe on the first start of the compressor, and this caused a spark and ignited the gas in the receiver.

I would like to have some readers of *Power* express their opinions as to how the gas or oily vapor in the tank was ignited. P. JONES.

Quebec City, Canada.

Boiler Capacity Limited by Stack Size

In the June 5 issue of *Power* L. M. H. states that his boiler capacity is greater when wood is used for fuel than with coal, and asks if it would not be practical to increase the grate area for obtaining more boiler capacity when coal is burned.

From the article it appears that the capacity obtained while using wood as fuel is ample and the aim is to obtain the same capacity with coal.

In order to make it easier for the reader to follow, it is necessary to establish a common ground before answering the question.

1. It is generally accepted that 1 lb. of coal of ordinary quality and in ordinary practice will evaporate about 7 lb. of water from and at 212 deg. F. or about 6.5 lb. under actual conditions.

2. In boilers equipped with ordinary furnaces, if efficiency of combustion is maintained, the output varies in proportion to the total coal used per hour.

3. Rate of combustion or pounds of coal burned per square foot of grate area per hour largely depends on draft intensity or height of the stack as well as size of the coal used.

4. Stack capacity is directly proportional to the area of the stack and velocity of the gases, which in turn varies as a square root of the draft drop or velocity head.

5. Resistance of a wood fuel bed will, as stated in the answer given, be much less than the resistance of a coal fuel bed developing the same amount of heat, due to greater voids in a wood bed. From this it is evident that the resulting gases per B.t.u. developed will be greater in cases where wood is used, than where coal is burned.

6. Increase of rate of combustion or fire thickness is followed rapidly by an increase of fuel-bed resistance; this is true particularly at low rates of combustion.

From the foregoing the following deductions can be made:

1. If capacity obtained with wood as fuel is satisfactory and we know that the weight of resulting gases in the case of wood are greater than with coal, per B.t.u. developed, then it is certain that the stack capacity, so far as the area of the stack is concerned, is not a limiting factor in cases where coal is used.

2. Effort to increase boiler capacity with coal as fuel naturally results in a thicker fuel bed. The thicker the fuel bed, naturally the greater draft intensity is required in order to deliver the required amount of air to consume properly the greater amount of coal per square foot of grate area per hour. If the draft required is not available, coal does not burn properly; coke gradually accumulates as the steam is being maintained by the gas fire from the volatile portion of the coal, and eventually the fuel bed gets so thick that it becomes heat-bound or inactive, and the formation of clinkers becomes rapid and the fire has to be cleaned, and in doing this the accumulated clinkers, as well as coke, is removed and the fire started on a new cycle. The limiting factor, from the foregoing, therefore, is inadequate draft intensity and the proper remedy is a higher stack. The stack height required will depend on the draft necessary to maintain the desired rate of combustion, under sufficient pressure in the ashpit to force enough air through the fuel bed.

In practice the capacity of the boiler or the total coal burned per hour can be varied by increase or decrease of rate of combustion per square foot per hour or by decrease or increase of active grate area. In case it is desired to burn more coal per square foot of grate area, the grate being already quite large, the remedy would be as pointed out—either increase the stack height or install forced draft.

In cases where the grate area is insufficient, it can be increased so as to burn more coal. With increase of grate area each square foot of added area, if fire is carried at the same thickness as before, will burn as much coal as any other square foot of grate area before it was increased, and the capacity of the boiler after the change is made should be in the same ratio as the area of the new grate to the area before the change was made.

Now, in the case in hand, the boiler is 60 in. in diameter by 16 ft. long. The grate is 5x5 ft., or 25 sq.ft. total grate area. There is no reason why the grate should not be 5x6 ft., or 30 sq.ft. and the capacity increased. Taking as a criterion the past performance of the plant, the rate of combustion now obtained will be $30 - 25 \div 25 = 0.2$, or 20 per cent greater than before. However, if this increase is not sufficient, the only recourse is, as previously suggested, a higher stack or forced draft.

Chicago, Ill. HENRY MISOSTOW.

Stoker Operating Methods

I have recently read several articles in different engineering publications on drafts and draft regulations in connection with the usual power-house furnace, stoker-fired with forced draft. It seems to me that they have failed in their object, which was to tell us how to operate our stokers to obtain the best results, by failure to emphasize the most important phases by burying them in a mass of technical details where only the man who already knew the subject could find it. Articles of this nature are of little value to the ordinary man that you find operating the stoker.

When I first took charge of the boiler room in this plant, it being my first experience in the operation of stoker-fired boilers, I was struck by the lack of any real boiled-down information that could be found on the subject. I could find a lot of information on the theory of combustion, etc., that I already knew, but when it came to telling us how to apply that theory to get the best results and be a real help or guide for the firemen, the writers seemed to be in a hurry to get through. Ninety-nine per cent of the firemen care nothing about a lot of curves on the relation of coal supply to air supply. What the average fireman wants to know is how fast to run his stoker. How much shall he open the stack damper? What wind box

pressure shall he carry? How heavy a fire shall he carry?

Every engineer knows that unless he can answer these questions he must leave it to the fireman's judgment, and that being the case, the efficiency of his plant is not likely to be very high unless he has been fortunate enough to obtain some experienced men. There is a point in stoker operation that I think is being neglected, one that I think a good many engineers fail tc realize the importance of, and that is fire-bed resistance.

In attempting to answer the fireman's questions and set a rule that was workable, several different things were tried. It was during these experiments that we discovered how well a stoker could be operated by using the fuel-bed resistance as a guide. The principal weakness was in the use of the forced draft with varying conditions of the fuel bed. However, out of it all we have developed a system that we have been using for over a year, and the results obtained seem to warrant passing the information along.

At our plant we are now obtaining a coal rate of about 1.9 lb. per kw.-hr. with an 18-lb. per kw.-hr. water rate, 206 lb. steam pressure and 125 deg. superheat, which if figured out will give us an over-all efficiency for boilers and stokers of better than 70 per cent, with a 13,500-B.t.u. coal and 200-deg. feed-water temperature.

Of course we realize that the evaporation per pound of coal can be improved, but we do not consider this performance half bad, especially as it is the average daily performance, when other things are taken into consideration, such as the cleanliness of the boilers outside and in, condition of the baffles, which are daily being improved, also the low setting of the boilers which gives too small a combustion space.

The firing rules are best explained by showing how we went about it. First, let me say that the boilers are equipped with the "balanced draft" system of back damper regulation for maintaining a constant draft over the fire, and a 3-in-1 draft gage. The boiler setting is first gone over and made as tight as possible, the draft gage checked to see if it is correct, then the balanced draft regulator is adjusted to maintain about —0.05 in. draft over the fire, the fire is cleaned and built up to the required thickness that best suits our conditions. Then without paying any attention to the draft gages the windbox pressure is adjusted with the aid of the hand Orsat apparatus until we get from 12 to 14 per cent CO_2, the amount depending on the kind of coal we are getting and the rate of combustion required. In this way we have obtained an almost ideal fire, and there is only one thing left to do and that is to maintain it.

The draft gages are then read and we will say, for example, that they read 2 in. in the windbox, —0.05 in. over the fire, —0.6 in. at the back damper. The fireman is then instructed to watch the stack damper and windbox pressure gage as they will be the two variables. He is instructed to hold the stack damper gage at 6 in. by adjusting the windbox pressure, and if he has to put more than 2 in. pressure in the windbox to obtain a reading of —0.6 in. on the stack gage, his fire is getting too heavy or dirty and the thing for him to do is either slow the engine or clean his fire as soon as possible. If he cannot put 2 in. of pressure on the windbox to obtain a reading of —0.6 in. at the stack damper, then his fire is too light or there are holes in it, and he must get the holes out by leveling the fire or speeding up the stoker, depending on the quantity of fire he has in the furnace.

We will say that the fire has just been cleaned and the fireman is ready to open his windbox damper, which he proceeds to do; only, instead of watching the windbox gage, he watches the stack gage and pulls the windbox damper open until he gets a reading of —0.6 in. on the stack gage. The windbox gage probably only shows a reading of 1 in.; then, as his fire shows light, he speeds up his stoker to get the fire up where it belongs. As the fire builds up, his stack gage begins to show that the stack damper is closing owing to the increasing resistance of the fuel bed, that calls for an increase in the windbox pressure in order to bring the stack gage back to —0.6 in. The operation is continued until he has reached the point where he can put a 2-in. pressure on the windbox and still maintain a stack opening of —0.6 in. when he has again reached the ideal condition. All that remains for the fireman to do is to watch his draft gage and run the stoker at a speed that will maintain the proper draft conditions.

If the coal is being fed too fast, the stack gage will show it by a lower reading, calling for more windbox pressure, which will raise the pressure over 2 in. If the coal is not being fed fast enough, the gage will show an increased opening, calling for less windbox pressure and a higher stoker speed until the normal conditions have been reached.

As to how it works out in practice, I think the results that I have already mentioned speak for themselves. The proper relation between windbox pressure and fuel-bed resistance is maintained at all times and we have better-looking steam charts than we have ever had before, owing to the steady steaming of the boilers. Due to the carrying of even fires we also get better results from our water tending and can get a higher temperature in the feed-water heater with the same amount of exhaust steam. Also a green man is not so much of a handicap, as it is comparatively easy to break him in under this system.

Peak loads can be taken care of by simply increasing the depth of the fires, thus permitting a little higher windbox pressure, but we try to anticipate the load so that we can keep enough boilers on to maintain the proper steam pressure without changing the rate of combustion.

A CO_2 recorder has since been installed and is piped up to six boilers. This is used as a check to see if the damper adjustments are O. K. If the damper adjustment has not been changed, we invariably find the same percentage of CO_2 that it was originally set for, and by checking the CO_2 recorder with the recording draft gage, which we have piped up to show the stack damper opening, it shows that as long as the stack damper opening is held constant, the percentage of CO_2 is constant also.

H. T. EDGCOMB, Combustion Engineer,
Brandywine Power Plants,
Wilmington and Philadelphia Traction Co.
Wilmington, Del.

It is hard to convince the safety inspector that your plant is positively safe if he finds a pile of rubbish in every corner and tools, oily rags and waste thrown promiscuously about. He knows that someone about the plant is negligent in regard to cleanliness. Insist on real and permanent action regarding cleanliness. It pays.

QUESTIONS AND ANSWERS

Conducted by Franklin VanWinkle

Tapered Furnace Sheet of Vertical Boiler

In some designs of vertical straight-shell fire-tube boilers, why are the furnace sheets tapered to a smaller diameter at the top than at the bottom? L. N. C.

This form of firebox is more generally used on larger sizes of vertical boilers where, to permit of internal inspection, the tubes are placed about one foot back from the shell. The outer portion of the upper tube sheet left unstayed by the tubes is provided with a circular row of braces, but to avoid the use of stays in the lower tube sheet, its diameter is reduced and the furnace sheet is sloped toward the center so the flanging of the tube sheet may be close enough to the tubes to make braces unnecessary.

Relative Draft Capacities of Chimneys

What would be the relative capacities of chimneys 4 ft. in diameter, 300 ft. high, and 8 ft. in diameter, 100 ft. high? G. E. T.

For the same temperature of chimney gases the draft capacities vary directly as the effective cross-sectional area and as the square root of the height. For round chimneys the effective area is assumed to be the area due to 4 in. reduction of the actual diameter.

Hence the draft capacity of the 4-ft. diameter by 300-ft. chimney would be to the draft capacity of the 8-ft. diameter by 100-ft. chimney as

$$\left((4 \times 12) - 4\right)^2 0.7854 \times \sqrt{300} \text{ to } \left((8 \times 12) - 4\right)^2 0.7854 \times \sqrt{100}$$

or about as 1 to 2.5.

Determining the Polarity of an Electric Circuit

When finding the polarity of an electric circuit by placing the terminals into water containing a little salt or acid to render it a conductor, will bubbles be formed on the negative terminal or on the positive? Why is it that the bubbles are formed on one terminal only. C. M. K.

When the two terminals of an electric circuit are placed in a weak salt or acid solution, gas is formed at both terminals. When copper is used, the oxygen liberated at the terminal units unites with the metal to form copper acids, therefore does not appear in the form of gas bubbles. At the negative terminal where hydrogen is liberated the gas does not unite with the metal and appears in the form of bubbles. If gold or platinum conductors were used, bubbles would form at both terminals, since neither gas unites with the metal. However, there would be twice as many gas bubbles from the negative terminal as from the positive.

Causes of Lower Efficiency at Light Loads

Why do engines require more steam per actual or brake horsepower for light loads than when loaded at their normal ratings? R. N.

Lower efficiency at light loads is due to a larger ratio of the friction load, loss of heat by radiation, and piston and valve leakage, all of which are practically constant at different loads and therefore constitute a larger proportion of loss at light loads; and when the power is regulated by varying the cutoff, there may be larger loss from cylinder condensation due to a wider range of temperature and pressure.

Tendency of Boiler Pressure to Push Mud Drum Off Nipples

In an inclined water-tube boiler how much pressure is there tending to push the mud drum off the nipples? O. N.

The boiler pressure tending to push the mud drum off a nipple is the water pressure per square inch at the nipple multiplied by the internal cross-sectional area of the nipple. However, in most inclined water-tube boilers the rear end rests on the mud drum and the tendency of the boiler pressure to push the mud drum off the nipples is opposed by reaction of the supports.

Special Requirement of Vacuum Pump

What is the difference in design of a vacuum pump and a boiler-feed pump and why is not a duplex type as suitable as a single pump? E. R.

The main difference is that the pump cylinder of a vacuum or air pump should be provided with as little clearance as consistent with construction and operation, whereas in a feed pump liberal clearance is of advantage in reducing friction of flow of water through the pump. The operation of a vacuum pump is similar to that of an air compressor. Air and uncondensable gases that enter the cylinder during the suction stroke are not discharged during the return stroke until compressed a little above the discharge pressure which, for the vacuum pump, is the pressure of the atmosphere. During the succeeding suction stroke more air cannot be drawn into the cylinder until the compressed-air lift in the clearance spaces at the end of the return stroke has expanded to the suction pressure. Hence, for efficient operation of a vacuum pump the clearance space should be as small as possible. As a vacuum pump a duplex pump is not so suitable as a single pump, since the duplex is likely to short stroke, resulting in reduction of capacity with increase of the clearance volume, whereas a single pump is bound to make a full stroke, as it cannot reverse before the piston has arrived at the end of the stroke.

Number of Expansions

How many expansions are there in a cylinder in which steam is cut off at three-eighths of the stroke?

R. G.

The number of expansions is the final volume divided by the volume present at cutoff, and roughly for cutoff at three-eighths stroke, the number of expansions would be $1 \div \frac{3}{8} = \frac{8}{3}$ or 2.66. But the actual volume present at cutoff consists of the volume of the clearance space plus the volume of piston displacement up to the time that cutoff takes place; and the final volume is the volume of the clearance space plus the volume displaced by a full stroke of the piston. Hence, if the clearance volume is 5 per cent of piston displacement per stroke and cutoff takes place at three-eighths or 0.375 of the stroke, the actual number of expansions would be $1 \div (0.05 + 0.375) = 2.35$.

Testing Valves of Vertical Ammonia Compressor

How can the tightness of the discharge valves of a vertical inclosed type ammonia compressor be tested?

W. L. M.

To test, close the ammonia suction stop valve and allow the machine to run about two minutes to evacuate all the gas from crankcase and compressor, and stop the machine when the compressor and crankcase are free from frost. If the machine is frosted, there is likely to be a small quantity of liquid lying in the bottom of the compressor, which will evaporate, causing pressure, and defeat the test. After the machine has been shut down 15 minutes, hold a thumb over the oil intake pipe and slowly open the valve to see if the suction indicates a good, strong vacuum. If so, the gas is all out of the compressor. If gas blows out, start the machine again and let it run as described until there is a strong vacuum. Next stop the machine and close the discharge stop valve and remove the water-jacket cover and compressor head. If the discharge valve is tight, it will be held fast to its seat, due to the vacuum in the compressor. If it is loose and there is no vacuum in the compressor, the valve leaks and will have to be ground in with flour of emery and oil. If this is done, care should be taken to see that all the emery is removed, otherwise it may get into the cylinders or bearings and do considerable damage.

Eccentric as Substitute for Main Driving Crank

What is the correct definition of an eccentric? If the crank of an engine has 2 ft. throw and this crank is removed from the shaft and replaced by an eccentric of 2 ft. throw, with straps mounted on the eccentric and the eccentric rod attached to the crosshead, would the engine operate?

J. E. S.

An eccentric is a circular disk, wheel or sheave mounted on a shaft eccentric to the shaft. An eccentric motion is a crank motion wherein the crankpin is so large that it encompasses the shaft. When this is the case, the connecting rod is called an "eccentric" rod and the connections of the rod with the crankpin corresponding with the ordinary connecting-rod crankpin brasses are called eccentric straps.

Referring to Fig. 1, assume that the crank on the engine shaft *S* has a throw or radius *SC* equal to 2 ft. When the center line of the cylinder passes through the center of the shaft, then *DB*, the diameter of the circle *ABCD* that is described by the center of the crankpin, must be equal to the length of stroke, regardless of the diameter of the crankpin. Hence, if the crankpin were to be made as large in diameter as the diameter of the dotted circle *E*, or even enlarged to the size of the circle *FGH* so as to include the shaft *S*, and thereby become an eccentric, the center *C* still would describe the crankpin circle *ABCD* for a complete instroke and outstroke of the piston and crosshead, since the throw *SC* remains the same.

Fig. 2 shows the crank and crankpin of Fig. 1 enlarged into an eccentric *FGH* with the crankpin

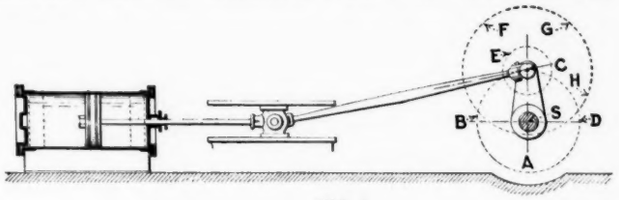


FIG. 1

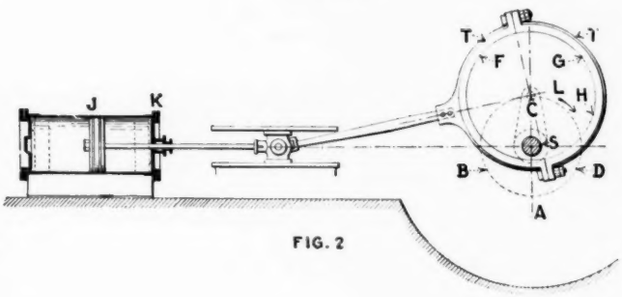


FIG. 2

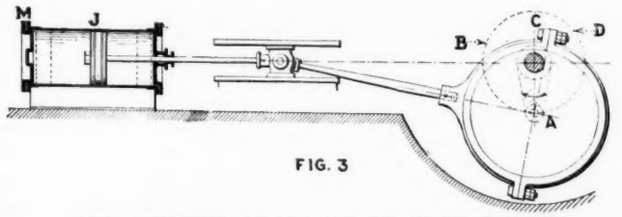


FIG. 3

REPLACEMENT OF CRANK BY AN ECCENTRIC

Fig. 1—Conditions unchanged from variation of crankpin diameter.

Figs. 2 and 3—Crankpin diameter expanded into an eccentric.

brasses at *C*, Fig. 1, converted into eccentric straps *TT* and the connecting rod, Fig. 1, converted into an eccentric rod. All other things being equal and with sufficient clearance for the eccentric strap, movement of the piston from *J* to *K* and return to *J* would carry the center of the enlarged crankpin through the semicircle *CDA* to the position *A*, Fig. 3. Continuing the stroke from *J* to *M* and return to *J* would complete the rotation of the shaft by bringing the center of the eccentric or enlarged crankpin around to the position *C*, as would be the case with an ordinary crankpin and same throw of crank shown in Fig. 1. Hence, geometrically, the engine would operate the same as with a crank of the same throw. However, for practical operation, an eccentric would be a poor substitute for a main driving crank on account of massiveness of the construction and large amount of friction caused by the relatively high velocity of the rubbing surface of the eccentric with respect to the bearing surfaces of the straps.

[Correspondents sending inquiries should give their full names and post office addresses. This is necessary to guarantee the good faith of the communications.—Editor.]

Easy Lessons in Engineering

How To Use the Steam Tables—II

Before proceeding to study the items for entropy and internal energy in the saturated steam tables, we should learn to use the tables for superheated steam. Table I is an extract from 115-lb. line of the superheated-steam tables. The four letters at the left have the following meaning: t, temperature, deg. F.; v, volume of one cubic foot in pounds; h, heat content above water at 32 deg.; n, entropy above water at 32 deg. (to be explained later).

The data in columns 3 and 4 are taken from the saturated-steam tables, as may be seen by comparison with Table II (same as Table I of first article). These show that, at 115-lb. absolute pressure, the temperature

TABLE I—EXTRACTS FROM "SUPERHEATED STEAM TABLE"

(1) Press., Lb.	(2)	(3) Water	(4) Sat. Steam	(5) Degrees of Superheat 10	(6) Degrees of Superheat 20	(7) Degrees of Superheat 100	(8) Degrees of Superheat 200
115	t	338.1		348.1	358.1	438.1	538.1
	v	0.02	3.88	3.95	4.01	4.51	5.09
	h	309.0	1,188.8	1,194.6	1,200.3	1,243.1	1,293.0
	n	0.4877	1.5907	1.5979	1.6050	1.6549	1.7075

of boiling water or saturated steam is 338.1 deg.; the volume of one pound, 0.02 cu.ft. for water and 3.88 cu.ft. for steam; the heat in one pound of boiling water (heat of liquid), 309.0 B.t.u.; the heat in one pound of saturated steam (total heat of saturated steam), 1,188.8 B.t.u.; the entropy of one pound, 0.4877 for the water and 1.5907 for the steam.

The remaining columns (only a few of which are shown) give the same quantities for one pound of steam at 115 lb. pressure with various amounts of superheat. For example, column 7 shows that for 100 deg. of superheat the actual steam temperature is 438.1 deg. This is evidently obtained by adding 100 to 338.1, the temperature of saturated steam. At this superheat the volume of one pound of steam is 4.51 cu.ft. Comparison with 3.88, the volume of one pound of saturated steam, shows that superheating expands the steam considerably.

The heat content is seen to be 1,243.1 B.t.u. This means that the total amount of heat required to raise one pound of 32-deg. water to the boiling point, evaporate it and superheat it 100 deg. is 1,243.1 B.t.u. at this pressure. Since it required 1,188.8 B.t.u. to produce dry saturated steam, the actual heat expended in superheating is only 1,243.1 — 1,188.8 = 54.3 B.t.u. In general, for all ordinary degrees of superheat, the amount of heat required for superheating is small, rarely exceeding 10 or 15 per cent of the total heat put into the steam. In this case it is less than 5 per cent.

It should be noted that the average amount of additional heat required for each degree of superheat is 54.3 ÷ 100 = 0.543. This quantity is the average specific heat of steam at 115 lb. pressure over the range from zero superheat to 100-deg. superheat, the specific heat of any substance being the amount of heat required to raise one pound of it one degree. It will be remembered that the specific heat of water is very close to 1 for all ordinary conditions. The specific heat of superheated steam varies much more widely, but the rough average value of 0.5 may be used for approximate computations when no tables for superheated steam are at hand.

Suppose, for example, it was desired to find the total heat of steam at 115 lb. absolute and 200 deg. superheat. The "saturated steam" tables give the total heat of dry saturated steam as 1,188.8 B.t.u., say 1,189 B.t.u. For 200 deg. of superheat add 200 × 0.5 = 100 B.t.u. giving 1,189 + 100 = 1,289 B.t.u. for the approximate total heat of the superheated steam. The exact value is seen to be 1,293.0 B.t.u., about one-third per cent higher.

The entropy of 115-lb. steam, with 100 deg. of superheat, is seen to be 1.6549. The uses of entropy will be explained later.

The simplest kind of problem involving the superheated-steam table occurs in figuring the efficiency of a boiler, as illustrated by the following problem:

Problem: A boiler produces 9 lb. of steam per pound of coal. The coal contains 13,500 B.t.u. per pound. The feed water is at 210 deg. Steam is generated at 100 lb. gage and 100 deg. superheat. What is the overall efficiency?

Heat in 1 lb. of steam at 115 lb. abs. and 100 deg. superheat ..... 1,243.1 B.t.u.
Heat in 1 lb. of water at 210 deg. (210 — 32)..... 178.0 B.t.u.

Heat to produce 1 lb. of steam (difference)..... 1,065.1 B.t.u.
× 9

Heat to produce 9 lb. of steam..... 9,585.9 B.t.u.

Therefore the boiler output is 9,585.9 B.t.u. for each pound of coal, or for each 13,500 B.t.u. of input. Since

TABLE II—EXTRACTS FROM "SATURATED STEAM-PRESSURE TABLE"

(1) Press., Lb.	(2) Temp., Deg. F.	(3) Press., Atmos.	(4) Sp. Vol. Cu.Ft. per Lb.	(5) Density Lb. per Cu.Ft.	(6) Heat of the Liquid	(7) Latent Heat of Evap.,	(8) Total Heat of Steam,	(9) Internal Energy B.t.u. Evap.	(10) Internal Energy B.t.u. Steam	(11) Entropy Water	(12) Entropy Evap.	(13) Entropy Steam
p	t	—	v or q	$1/v$	h or q	L or r	H	I or ρ	E	n or θ	L/T or r/T	N or ϕ
1	101.83	0.068	333.0	0.00300	69.8	1,034.6	1,104.4	972.9	1,042.7	0.1327	1.8427	1.9754
14.7	212.00	1.000	26.79	0.03732	180.0	970.4	1,150.4	897.6	1,077.5	0.3118	1.4447	1.7565
15	213.0	1.021	26.27	0.03806	181.0	969.7	1,150.7	896.8	1,077.8	0.3133	1.4416	1.7549
20	228.0	1.361	20.08	0.04980	196.1	960.0	1,156.2	885.8	1,081.9	0.3355	1.3965	1.7320
65	298.0	4.423	6.65	0.1503	267.5	911.0	1,178.5	831.4	1,098.7	0.4344	1.2024	1.6368
115	338.1	7.83	3.88	0.2577	309.0	879.8	1,188.8	797.9	1,106.5	0.4877	1.1030	1.5907
215	388.0	14.63	2.138	0.468	361.4	837.9	1,199.2	754.0	1,114.6	0.5513	0.9885	1.5398

efficiency is output divided by input, we shall have:

$$Efficiency = \frac{output}{input} = \frac{9{,}585.9}{13{,}500} \text{ 0.71, or 71 per cent}$$

Another type of problem involving the use of both the saturated and superheated tables is that in which steam is throttled. Except at initial pressures above 500 or 600 lb., the passing of dry saturated steam through a reducing or throttling valve always superheats it. The reason is that steam passing through such a valve has its pressure reduced without doing any external work. The velocity produced is soon used up in internal friction with the final result that the throttled steam contains exactly the same amount of heat as at the start. Saturated steam at the lower pressure has a lower total heat, so the steam must be superheated to contain the same amount of heat as at the start.

Suppose dry saturated steam at 200 lb. gage is throttled to 100 lb. gage. The total heat of saturated steam at 215 lb. absolute is 1,199.2 B.t.u., so this must also be the total heat of the final steam at 115 lb. Table I shows that saturated steam at 115 lb. absolute contains only 1,188.8 B.t.u., so it is necessary to look for a degree of superheat that will give 1,199.2 B.t.u. This is seen to lie between 10 deg. and 20 deg. Interpolation gives 18 deg. If no superheated-steam tables were available, the problem could have been solved roughly as follows:

Total heat saturated steam at 215 lb. abs.....1,199.2 B.t.u.
Total heat saturated steam at 115 lb. abs.....1,188.8 B.t.u.

Difference to be made up by superheat..... 10.4 B.t.u.
Amount of superheat = 10.4 × 2 = 21 deg. approximately.

The difference was multiplied by 2 because one B.t.u. will superheat one pound of steam approximately two degrees, assuming the approximate value of 0.5 for the specific heat of superheated steam.

The reader should now be fairly familiar with the every-day uses of all the steam-table items except "internal energy" and "entropy," as given in columns 9 to 13 of Table II.

Column 9 gives the internal energy of evaporation, represented by I or ρ (a Greek letter pronounced "rho").

This is the part of the latent heat of evaporation (column 7) that is stored up inside the steam in pulling the molecules apart against their mutual attractions. The remainder of the latent heat is used up in external work, such as pushing a piston, in the expansion of water into steam. For example, at atmospheric pressure 14.7 lb. absolute) the latent heat of evaporation is 970.4 B.t.u. and the internal energy of evaporation 897.6 B.t.u.

The latter quantity is computed by figuring the amount of external work alone, reducing it to B.t.u., and then subtracting it from the latent heat. For example, column 4 shows that a pound of water will expand to 26.79 cu.ft. of steam at this pressure. The external work done by this expansion is 56,600 ft.-lb. Since 778 ft.-lb. are equal to 1 B.t.u., this will use up 56,600 ÷ 778 = 72.8 B.t.u., leaving 970.4 — 72.8 = 897.6 B.t.u. for internal energy as given in column 9.

In raising water up to the boiling point, the external work done by expansion is practically zero, so the entire heat of the liquid, 180 B.t.u. goes to internal energy. Therefore, the total internal energy of the steam (measured above water at 32 deg.) is 897.6 + 180 = 1.077.6 Column 10 gives 1,077.5, which practically checks with the value just computed.

Practical problems involving internal energy are rarely encountered in every-day work. This, however, is not true of entropy, which is a most important quantity, although somewhat difficult to understand. *No attempt will be made to explain entropy here except to say that it is a quantity that remains constant in what is called "adiabatic" expansion.* This is the kind of expansion that would occur in a perfect imaginary steam turbine in which all friction, eddy currents, windage, radiation, etc., were eliminated, or in the cylinder of a perfect steam engine in which the walls and piston were complete insulators. While actual engines and turbines must always fall short of this ideal condition, it is frequently used as a standard with which to compare an actual engine or turbine working under the same conditions.

Columns 11, 12 and 13 give the entropy of water at the boiling point, the entropy of evaporation and the entropy of saturated steam respectively. Column 13 is the sum of 11 and 12.

To illustrate the use of entropy, suppose we wish to figure the over-all thermal efficiency of an imaginary power plant consisting of a perfect boiler, a perfect engine and a perfect condenser, the condensate being fed directly to the boiler. Say that the boiler produces dry saturated steam at 215 lb. absolute and that the engine exhausts at one pound absolute.

Since the engine is perfect, the expansion is "adiabatic," meaning that the entropy of the exhaust steam is the same as that at the throttle. From column 13 the entropy at the throttle is seen to be 1.5398. This, then, must also be the entropy of the exhaust steam. At one pound absolute the entropy of dry saturated steam is 1.9754. The exhaust steam must therefore be wet in order to have the total entropy only 1.5398. Suppose that the fraction x of the steam is dry (that is, actually evaporated). Then the entropy of 1 lb. of exhaust steam will be the entropy of 1 lb. of water plus x times the entropy of evaporation. The total must equal 1.5398, so we have

$$0.1329 + 1.8427x = 1.5398$$
$$1.8427x = 1.5398 - 0.1329 = 1.4069$$
$$x = \frac{1.4069}{1.8427} = 0.761$$

Since the exhaust steam is 0.761 dry, its heat must be (see columns 6 and 7): 69.8 + (0.761 × 1,034.6) = 69.8 + 787.3 = 857.1 B.t.u. With an initial total heat of 1,199.2 B.t.u., the turbine would abstract from each pound of steam 1,199.2 — 857.1 = 342.1 B.t.u. The perfect boiler receiving feed water with 69.8 B.t.u., would have to supply 1,199.2 — 69.8 = 1,129.4 B.t.u. in the form of fuel. Therefore the output of the perfect plant would be 342.1 B.t.u. for every 1,129.4 B.t.u. supplied, so the efficiency would be $\frac{\text{output}}{\text{input}} = \frac{342.1}{1{,}129.4} = 0.303$, or 30.3 per cent.

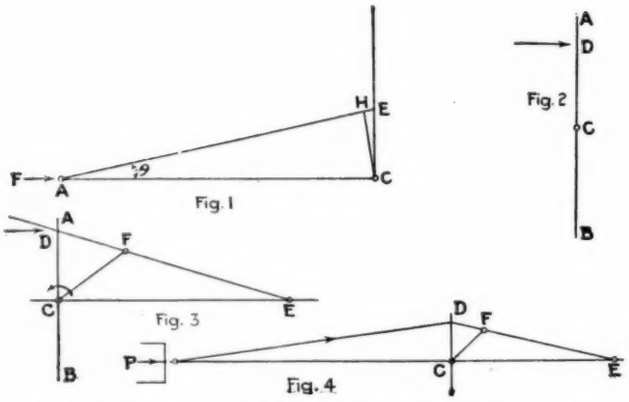
This is the over-all efficiency of a plant consisting of a perfect engine, perfect condenser and perfect boiler under the given conditions. It is also the "thermal efficiency" of a perfect turbine or engine.

In fact, the term "thermal efficiency" as applied to any engine or turbine, whether perfect or actual, is merely the ratio of the heat turned into useful work by the prime mover to that which a perfect boiler would require to produce a pound of throttle steam from a pound of condensate at exhaust saturation temperature. In other words, to figure the thermal efficiency of any engine, imagine it connected with a perfect condenser and perfect boiler and figure the over-all efficiency of the plant. The answer will be the thermal efficiency of the engine.

Indicator to Measure Mean Effective Pressures

The steam-engine indicator gives a diagram whose average height is proportional to the mean effective pressure and whose area is proportional to the work done on the piston by the steam.

To arrive at the work done the average height must be obtained by some system of ordinate measurement or by planimetering the diagram area. This is not objectionable



FIGS. 1 TO 4—DIAGRAMMATICAL CONSTRUCTION OF TIME-PRESSURE DEVICE

in case of a few diagrams, but it does entail a large amount of effort if a lengthy test is being conducted. To obtain the mean effective pressure by direct reading, H. E. Wimperis, superintendent, Air Laboratory of England, has designed a novel and accurate instrument which is described in *The Engineer*, London.

Bourdon Gage for Measuring Pressures

The most familiar instrument for measuring pressures is a Bourdon gage; this contains a copper tube of oval cross-section bent to a nearly circular form. Fluid pressure inside this tube changes its curvature, and this change of shape causes a pointer to move over a scale graduated in whatever pressure units may be convenient. If, to an apparatus of this kind, a heavy disk be added in such a way that the angular motion of the pointer causes the disk to turn through a suitable angle, the response of the gage to changes of fluid pressure can be made to be very slow. By increasing or decreasing the mass and radius of this inertia disk, the response can be made slower or faster as may be desired.

It is known that the forced oscillations induced on an inertia mass controlled by a spring (the bent copper tube in this case) are very small when the period of the forcing oscillation is small compared with the period of the free oscillation of the instrument. If the inertia mass be designed to have a period of oscillation twenty times the period of the forcing oscillation, in this case the stroke speed of the engine, the motion of the pointer of the gage will be almost negligible and will take a position corresponding to the time average of the pressure changes in the engine cylinder.

In an actual engine, by reason of the crank and rod mechanism, the piston speed is not uniform but varies with the crank position, and it is necessary to have the stroke average rather than the time average of the pressure.

In the design, Fig. 1, AH represents the connecting-rod length, and its position when at an angle θ, and CH represents the crank arm. As is well known, the turning moment about C is proportional to $P \times EC$, where P is the total cylinder pressure. This is also proportional to the average torque, and EC is proportional to the piston velocity. Hence, if the force exerted on the piston be multiplied by a factor proportional to EC before it is conveyed as a couple to the inertia mass of the instrument, the latter will indicate the time average of the torque which is proportional to the stroke average of the pressure.

If the connecting-rod crank ratio of the engine be large, the motion of the piston will be very nearly a simple harmonic motion, in which case the piston velocity will also approximate to a similar motion with a difference in phase of $\frac{\pi}{2}$.

Imagine a vertical lever AB, Fig. 2 pivoted at C, receiving a variable force acting at D in a direction perpendicular to the lever. Imagine further that the point D of application of this force oscillates between A and B in a simple harmonic motion. The resulting variable couple about the pivot C will approximate to the desired mechanism and for many purposes its accuracy would suffice.

Strictly speaking, the distance DC in the diagram should be proportional at all times to the distance EC in Fig. 1 and for this it would suffice to provide in the measuring device a small model of the main engine mechanism. Thus CF is a miniature crank and EF a miniature connecting-rod (of the correct length ratio). The crank CF, Fig. 3, would be caused to rotate about C at the same speed as the engine; and the connecting rod, produced as necessary, would cause the point D, where the normal force is applied, to oscillate between A and B in such a way that the length would always be proportional to the piston velocity.

In practice the connecting rod EF, Fig. 3, would have part of its length slotted to contain a sliding pin representing the point D, the rod AB being similarly slotted for the same purpose. It would remain to insure that the force applied at D should be always perpendicular to the mean position AB. If it were applied by a straight rod fastened at its other end to the pressure-receiving device, piston or other apparatus on the line EC produced, as shown in Fig. 4, a further possible source of error would be introduced, but this with a rod of suitable length could be reduced within any desired limits or avoided altogether by making use of the null method of reading.

Model Made to Read Time Average

An experimental model was made to read the time average of the pressure, by attaching to the pointer mechanism of an ordinary Bourdon pressure gage a suitable inertia disk. From what has already been said, it will be clear that this was only a rough approximation to the ideal design. It had,

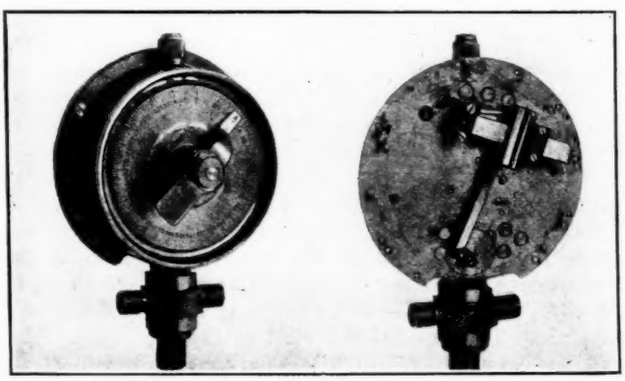


FIG. 5—CONSTRUCTION OF MEAN EFFECTIVE PRESSURE GAGE

however, the advantage of being very readily prepared and of affording some indication of the soundness of the principle upon which the design was based.

The next model also made use of a Bourdon pressure gage, but had the point of application of the force oscillated in a simple harmonic motion in tune with the engine revolutions. The apparatus, rough as it was, indicated quite steadily and showed at once the increase in the stroke average of the pressure as the throttle was opened. In the stroke average apparatus the pressures on the return strokes are, of course, subtracted automatically from those on the outward strokes,

an essential point of difference from the time average instrument in which all pressures are accounted positive at whatever timing they occur.

In both forms of the instrument as so far described the Bourdon tube got very hot—even though cooled by circulating oil—and soon lost its accuracy of calibration. In the working model shown in Fig. 5, the Bourdon tube was replaced by a small indicator piston and the angular motion of the inertia disk was controlled by a coil spring attached to it and to the case of the instrument. This model suffered from the disadvantage that it was made up from parts of a gage intended for another purpose, and involved the use of overhung pins and rocking levers which introduced an undue amount of friction into the apparatus. It was, however, considered accurate enough to show whether the scheme was worth proceeding with. It was decided to test the instrument on a single-cylinder Benz engine. It was first calibrated by being subjected to a steady oil pressure with the reciprocating pin at its maximum travel. The deflections were found to follow a linear law, and on multiplying the scale by $\frac{2}{\pi}$ the corresponding deflection due to any particular pressure when the torque arm followed a simple harmonic motion was obtained. The free period of oscillation of the inertia disk under the spring control provided was 2.2 seconds, corresponding to 27 vibrations per minute; this with an engine speed of 270 revolutions per minute and over would mean that the needle would oscillate through 1 per cent or less of the oscillations of the pressure. The instrument was then attached to the engine and the latter motored round; the correct phase adjustment was obtained by changing the setting of the phase box until the instrument read zero, that is, successive expansions and compressions of the air in the engine cancelling out. The engine was then run under its own power and a brake load applied. Readings of the mean pressure indicator were taken, at various brake loads, by the null method of reading previously described.

It was found that the instrument, in spite of its rough construction, gave readings well within the allowable range of error.

Lower Line Loss with Superheated Steam*

The accompanying table gives the results obtained in a series of four tests made by the Rochester Gas & Electric Corporation to determine the relative effects of saturated and superheated steam on the heat-insulation loss of steam mains. A 10-in. extra heavy high-pressure feeder line was chosen for the tests, which was so connected at the power station that either saturated or superheated steam could be supplied. The section tested was 1,250 ft. long, of continuously welded pipe with two 90-deg. bends of 10-ft. radius and two deflections of about 45 deg. also with 10-ft. radius bends. The line was of overhead construction supported on towers or hung from brackets, and was insulated by 1½ in. of 85 per cent magnesia next to the pipe, then 2 in. of hair felt, and made weather proof with covering of rubberoid roofing material. The line was graded to drain with the flow of steam for about 1,100 ft., at which point a drip pocket with trap connection was welded into the line. Beyond this point the line ran up a hill at an angle of 45 deg. for a distance of about 150 feet.

At each end of the section to be tested, instruments were installed to read the pressure, temperature and flow of the steam. A condensation meter was installed for measuring the discharge from the steam trap connected to the drip-pocket, and a surface condenser was placed between the trap and the meter to condense all vapor flashing off from the hot condensate, thereby enabling the condensation meter to measure all condensate removed.

Test No. 1 was made during July, 1922, at the time the line was completed. After the line had been under pressure for one week without load, the condensation meter on the drip pocket was set at zero and readings taken for a period of five days. It was assumed the number of pounds of steam supplied was equal to the number of pounds of condensate removed. The steam, supplied at an initial pressure and temperature of 180 lb. gage and 439 deg. F., had 1,234.5 B.t.u. per lb. The condensate collected in the drip pocket at 380 deg. had 352.7 B.t.u. per lb. The difference of 881.8 multiplied by 315, the pounds of condensate removed per hour, gave the total heat units lost per hour. This, divided by the external surface of the steel pipe times the difference in temperature between the average steam and the atmosphere equaled, for this test, 0.233 B.t.u. per hour per square foot per degree difference of temperature between steam and atmosphere.

Test No. 2 was made May 5 to 7, 1923. The line had been operated continuously for several months under superheat conditions, but on May 4 at 12 o'clock noon it was changed to saturated steam and 24 hours allowed for the heat insulation to adjust itself to the lower temperature. On the next day the valves at the far end of the line were closed and kept closed for a period of 43 hours. The result obtained showed a loss of 0.219 B.t.u. per hour per square foot per degree difference of temperature, which practically agrees with Test No. 1, run nine months previously.

SATURATED VS. SUPERHEATED STEAM

Test No.	1	2	3	4
Duration of test	5 days	43 hour	30 min.	30 min.
Quality	Superheated	Saturated	Superheated	Superheated
Av. initial pressure, lb. gage	180	195	194	191.4
Av. initial steam temp., deg. F.	439	386	488	463.7
Av. final pressure (1,250 ft. distant), lb	180	195	193	190.5
Av. final steam temp., deg. F.	380	386	463	441.3
Av. line temp., deg. F.	409.5	386	475.5	452.5
Av. outside temp., deg. F.	70	55	57	58
Condensate per hour, lb.	315	303.5	.....	.....
Steam flow, lb. per hour	315	303.5	12,550	18,058
Temp. condensate bei .e removed, deg. F.	380	386	.....	.....
B.t.u. in 1 lb. initial steam	1,234.5	1,198.8	1,259.4	1,246.9
B.t.u. in 1 lb. final steam	.....	.....	1,246.2	1,234.8
B.t.u. in each lb. condensate	352.7	359.2	.....	.....
B.t.u. lost each lb. final steam	.....	13.2	12.1	.....
B.t.u. lost each lb. condensate	881.8	839.6	.....	.....
B.t.u. lost per hour per sq.ft. per degree difference in temp.	0.233	0.219	0.113	0.157

Tests Nos. 3 and 4 were run with superheated steam throughout the line under low load conditions. The method used was to determine the heat content per pound of steam at the beginning and end of the line by means of pressure and temperature measurements, the difference representing the heat loss per pound of steam flow.

Test No. 3 showed a loss of 0.113 B.t.u. per hour per square foot per degree difference while test No. 4 showed a loss of 0.157. It is impossible to account for this wide variation in results unless it be that Test No. 3 was made after the line had been under this same temperature for several months, while previous to starting Test No. 4 the line had been at the superheat temperature for only twenty-four hours, it having been operated at saturated steam temperature from May 4 to May 10.

The results, however, indicate a material reduction in heat loss when the steam is superheated before being delivered to the distribution system. The B.t.u. loss per hour per square foot per degree difference in temperature with superheated steam is only about 60 per cent of the loss for saturated steam. In addition to this there is a further loss in the case of saturated steam due to the fact that the water of condensation, which collects in the line, is trapped out and drawn away. In the case of Tests Nos. 1 and 2 this amounts to over 300 lb. per hour.

Several factors may account for the difference in the heat coefficient between saturated and superheated steam. It is known that the coefficient of heat transmission for superheated steam is lower than for saturated steam. In addition to this and probably of greater importance is the fact that with superheated steam the inner surface of the pipe line is in all probability dry and the rate of transmission of heat from the core of steam inside the pipe to the inner surface of the pipe itself is much lower when that inner surface is dry than when it is wet.

Don't neglect to keep direct expansion cooling coils free from frost. Melt it off by running hot gas through them. Don't neglect the compressor cylinder valves and false head, if it has any. Watch for broken or weakened springs.

*Excerpt from report of Station Operating Committee of the National District Heating Association.

Zinc in Boilers

An inquiry regarding the use of zinc in boilers addressed to the Boiler Code Committee of the American Society of Mechanical Engineers brought out the following statement from the subcommittee on the Care of Steam Boilers and other Pressure Vessels in Service, of which F. M. Gibson is chairman:

Zinc is used in boilers for two reasons—the prevention of scale and the prevention of corrosion.

As a preventive of scale there is conflicting evidence of its value. In some cases it is positively harmful and should be used with caution. Where it can be used safely, the same results can be obtained more positively by the means of feed-water treatment. It is of most benefit in selenitic waters, also where the scale consists of organic matter and lime and where sulphates and chlorides are in excess over carbonates. If only organic matter is present in the water, and zinc is used, a hard scale is formed which frequently causes overheating. Carbonate of lime, carbonate of magnesium or carbonate of iron quickly renders the zinc brittle and porous and reduces it to powder. Zinc should not be used where feed-water compounds are used.

As a preventive of corrosion the use of zinc has been successful where there existed electrolytic action, air in feed water or hydrochloric acid evolved from chloride of magnesium in sea water. Where used to counteract the action of air in feed water, it should be placed near the entrance of the feed.

Zinc should be used only upon the advice of a chemist who is familiar with feed-water treatment.

The amount of zinc to be installed depends upon the conditions involved and ranges from 0.5 to 1.0 square foot of exposed surface, not including edges, to each 100 square feet of heating surface.

Zinc slabs should be made of ½-in. thick rolled plates and should be in good electrical connection with the metal of the boiler by means of copper wire or other good conductor of low electrical resistance. Where straps are used to hold the zinc in place, they should be filed bright where in contact with zinc and boiler material; after being bolted in place, the outside joints should be protected with red-lead putty. The joint between bolts and zinc should be made tight by means of red-lead putty.

Baskets, troughs or pans should be used to catch any disintegrated zinc. When a boiler, in which zinc is used, is opened for inspection, the zinc should be inspected, and if any oxidized zinc is found, the zinc should be scraped or renewed. When its thickness has been reduced to ¼ in., the zinc should be discarded and new zinc installed.

Attached is a digest of several references:

REFERENCES

1. Kent—1900—page 720: Zincs are often used, their action is electrical, hydrogen going to the iron shell, and the oxygen to the zinc. It is supposed to prevent corrosion. In numerous cases the action has been harmful. Where scale consists of organic matter and lime, the action has been beneficial. With organic matter alone there is a tendency to make hard scale of zinc oxide and organic matter, enough so as to cause overheating.

2. Tulley—page 107: Zincs are used in boilers to prevent corrosion and to prevent scale. It is used to prevent corrosion mainly in marine boilers. It is used to prevent scale mainly in boilers fed with fresh water. A perfect metallic contact must be insured. Used for the prevention of scale, the theory is that particles of zinc wasted away mixed with solid matter in water and prevented adhering in the form of hard scale. Now generally believed that it acts electrically to prevent corrosion as well as scale. When water contains an excess of sulphates or chlorides over the carbonates, the acids of the former form soluble salts with the oxide of zinc. If the water contains mostly carbonates, there is no great amount of reaction. In externally fired boilers zinc should be used with caution, as it is liable to produce a heavy sludge leading to overheating. The evidence is very conflicting.

3. Helios—Heine Boiler Co.—page 49: . . . in ocean service some sea water is apt to be fed, which sets up electrolytic action. Zinc plates are, therefore, placed in the drum to act as the electro-negative agent and prevent corrosion. In the Heine Marine Boiler, the U. S. Navy standard is used; that is, ¾ sq.ft. exposed zinc for each 100 sq.ft. heating surface. A perfect electrical contact is insured and a pressed-steel basket is provided to catch the disintegrated zinc.

4. Christie—page 137: Dr. Kossman says that the use of zinc in boilers for the prevention of scale is useful in selenitic waters, but as against the carbonate of lime, carbonate of magnesium and carbonate of iron, it is of little value, the zinc quickly rendered porous, brittle and reduced to powder.

Dr. Moore says the most important result from the use of zinc is the protection of the plates from hydrochloric acid evolved from the chloride of magnesium in the sea water.

Dr. Corbigny says the galvanic action liberates hydrogen which lies close to the boiler metal, and prevents scale from adhering.

Dr. Worlington says zinc removes oxygen from the water; 13 pounds of zinc results in zinc oxide and will remove 3.2 pounds of oxygen from one ton of water.

5. "Marine Steam" says the use of zinc appears still a very important element of protection against corrosion due to air in feed water. It is recommended as a positive benefit suspended near entrance of feed as it deflects to itself from the iron harmful action. Charles H. Haswell suggested the use of zinc in marine boilers thirty years before the English engineers recommended the same thing.

6. "Gill's Engine Room Chemistry," page 92: Pitting may be prevented by the introduction into the boiler of plates of zinc, which is dissolved in plate, being frequently done in marine boilers. They must be bolted onto projections from the boiler itself, making a good electrical contact. For new boilers allow one square foot of zinc to each 50 sq.ft. of heating surface and later one-half this amount.

Injury in Oiling Running Engine

BY A. L. H. STREET

To stop or not to stop an engine in oiling it, that is the question, as Hamlet probably would have stated it had he been a stationary engineer. It is the question that was put to the United States Circuit Court of Appeals in the case of Woolfe vs. Ohio Oil Co., 286 Federal Reporter, 329.

The plaintiff was employed by the defendant to operate a gas engine used in pumping oil wells, and was injured through his clothing catching on an unguarded and revolving projection on the machinery.

In a suit to recover damages on account of the injury, one of the questions raised was whether or not a pumping station is a "shop" or "factory" within the meaning of the Ohio statute providing for the guarding of machinery in such establishments. Deciding the point in the affirmative, the court declared that a definition in the statute of "shops and factories" is broad enough to include any building in which there are mechanical appliances or machinery contemplated by the section which requires guards, etc.

The principal point debated in the suit was whether the plaintiff was guilty of contributory negligence in oiling the engine while it was running. The trial judge directed a verdict in favor of the defendant on the ground that the plaintiff's own fault was conclusively established. But, reviewing the case, the Circuit Court of Appeals reversed the decision, holding that it might have been properly found by the jury that the plaintiff acted with reasonable prudence for his own safety. The Circuit Court of Appeals said:

Negligence is never presumed, and the burden of proving negligence, by a preponderance of the evidence, rests upon the party asserting it. The question of the existence of contributory negligence is a question of fact for the jury. Where there is a conflict of evidence or where there is any doubt as to the deductions that may be drawn therefrom, the question should be submitted to the jury. . . .

In this case there is a substantial conflict in the evidence as to which is the safer method of oiling this engine. That question should have been submitted to the jury. There is practically no dispute in the evidence that the plaintiff at the time of his injury was oiling this engine in the usual and ordinary way in which it had been oiled for a number of years before and since the accident, and even if the jury had found that it would have been a safe way or a safer way to stop the engine before attempting to oil it, the further question should have been submitted to it whether the plaintiff, in the exercise of his judgment as to the safer way, was guilty of contributory negligence in adopting the usual and ordinary method that had been employed in the performance of this service, upon this lease, for substantially four years prior to the accident and which he had observed that his predecessor had adopted when he went there in company with the defendant's superintendent, Chapman, and at Chapman's request, for the purpose of becoming acquainted with his duties.

Evidence was introduced on the part of the defendant tending to prove that the plaintiff could have oiled this engine with safety to himself by stopping it during the oiling operation and starting it again after the oil had been supplied; that the engine could have been stopped by giving a quarter turn to the lever of the gas valve to shut off the gas and almost as easily started again; that the plaintiff did not adopt this safe method of performing his work, but undertook to oil the engine while it was in operation.

The plaintiff introduced evidence tending to prove that the starting of this engine was dangerous for the reason that it was necessary for him in starting it to throw his full weight upon the large flywheel by "tramping" upon the spokes to force compression of the gas in the engine cylinder; that when the gas exploded in the cylinder it started the flywheel in the opposite direction; that unless the operator was exceedingly vigilant and active he would be thrown by the recoil of the flywheel into the machinery and unprotected gears or against the side of the engine house; that upon one occasion he had been so thrown from the flywheel of the engine against the side of the building; that the starting of this engine presents a further danger in that immediately after it is started it is necessary for the operator to reach over the exposed projecting parts of the revolving machinery to adjust the screws and gage controlling the supply of gas; and that this is equally as dangerous as oiling the engine while in motion.

New Theory of Condenser Corrosion Suggests Remedy

Research work recently carried on by three British organizations—the Department of Industrial and Scientific Research, the British Electrical and Allied Manufacturers' Association and the Brass and Copper Tube Association—has not only brought out much new information regarding one particularly serious type of condenser-tube corrosion, but has apparently pointed the way to a simple remedy. The particular type of corrosion considered was that due to undissolved air entangled in large quantities in sea water or other water containing a high percentage of salt. The corrosion attacks only the tubes in certain plate areas and is confined almost entirely to the first three or four feet of the tubes and to the portions more than thirteen feet from the inlet (in the case of very long tubes). The principal remedy suggested is to keep the tubes for a week in sea water at 100 deg. F. before putting them into regular service. During this preliminary treatment the water should be stagnant or only slowly moving.

The following digest of the research work is based upon the report of Guy D. Bengough in the July 6 issue of *The Engineer* (London).

The investigation has been carried out under the direction of the Corrosion Research Committee of the Institute of Metals, and a voluminous report of the work will soon be presented to one of the engineering societies interested in the matter. The investigation was confined entirely to the corrosion caused by the presence of entangled air in the circulating water (sea water or salty water).

This variety of corrosion is particularly serious because it can cause tube failure in a few weeks. The rapidity of the action seems to be little affected by the composition of the tubes. The corrosion is characterized by being mainly located in the first three or four feet of the tubes and in the portion more than thirteen feet from the entrance, and by being free from the corrosion products, so that it looks very much like ordinary erosion by water flow. Other characteristics are that the corrosion is limited almost entirely to the tubes in certain restricted areas of the plates, and that electrolytic protection does not stop it.

In the writer's experience tubes have failed, due to this cause, in as little as seventeen days. Several instances have occurred of failures within six weeks, and failures within a year have recently become fairly common. Tubes that have lasted more than two years in a condenser have rarely shown all the characteristics of the action outlined. Lowered temperatures and increased water velocities both seem to increase this corrosive effect, which is therefore particularly serious in modern high-vacuum plants.

Extensive experiments seem to demonstrate pretty well that the cause of this type of corrosion lies not so much in the composition of the tube as in the conditions to which it is exposed. By observations of glass tubes and by subjecting condenser-tube material to the flow of sea water containing various quantities of entrained air bubbles, it has been conclusively shown that the corrosion near the entrance of a tube is due to the water entering at such an angle or in such a turbulent manner that the bubbles were thrown against the side of the tube. As the water flows along the tube, the bubbles gradually work toward the center, whereupon the corrosion is greatly reduced. At the same time there is a continual reduction in the size of the bubbles, which factor in turn increases the corrosion again after about thirteen feet of the tube has been traversed.

It should be noted that this type of corrosion is not due to the *dissolved* air that enters so often into corrosion discussions, but to the large amount of *entrained air* found in foaming sea water. The three most important factors seem to be the amount of this air, its state of subdivision (the finer the bubbles the worse is the corrosion) and the manner in which the bubbles impinge on the side of the tubes.

The action seems to consist mainly in the removing of the protective scale. One obvious way to reduce this difficulty is to eliminate air leaks in the circulating-water suction line.

It is also characteristic of this kind of corrosion that it affects the tubes in certain sections of the tube sheet, so that tubes in these sections may have to be replaced frequently, while those in other sections are practically unaffected. This is doubtless due to the fact that the flow distribution leads the air bubbles mainly to the tubes in the affected sections. When such troubles occur, it is important to keep an accurate record of tube replacements, showing the exact location of each tube, preferably on a large drawing of the tube sheet.

In replacing tubes in the affected section, much benefit may be expected from the use of tubes that have already acquired a protective coating. These may be obtained by transfer from the unaffected part of the condenser or by giving the new tubes a special treatment for a week in stagnant sea water at 100 deg. F. In either case a protective film is formed.

Efficiency Tests Made on 55,000-Hp. Hydro-Electric Units

In the revision for record of H. G. Acres' paper, "Refinement of Design of Large-Capacity Turbines," presented before the Spring meeting of the A.S.M.E., an abstract of which appeared in the July 24 issue under the title "Efficiency Tests Made on 55,000-Horsepower Hydro-Electric Units," three changes have been made in the last paragraph of the article by the author. The words "and uniform section" in the 5th line, "of uniform section" in the 10th and 11th lines, and "an instantaneous" in the 15th line, have been omitted from the last paragraph, which makes this paragraph read as follows:

The use of the Gibson process is limited to conditions that are properly conducive to the production of the phenomena upon which the theory is based, the first essential being a closed pressure conduit of reasonable length. In short conduits of, say, 50 to 60 ft. in length, more especially if they have at the same time a non-uniform section, it becomes necessary to apply correction factors that have a greater relative influence on the ultimate accuracy of the result than is the case with long conduits. The recently devised Allen "salt-velocity" method of measuring flow is susceptible of application to short as well as long conduits and to non-uniform as well as uniform sections, the accuracy of the final result being dependent, not on pressure rise, but on the refinement of the equipment applied to the injection of a salt solution, the time of passage of which, through a fixed length of conduit, forms the basis of the final computation. The writer is not sufficiently familiar with this method to attempt a detailed description, but recent practical applications appear to indicate that it has a really useful function and will become a generally recognized process as related to this branch of hydraulic engineering.

News in the Field of Power

Scope of Coal Storage Study Being Made by the F. A. E. S.

The Federated American Engineering Societies has sent out, through subcommittees, a comprehensive questionnaire covering the Storage of Coal, which is to be placed in the hands of coal consumers to be filled out. It has also sent to the subcommittees, an outline for a report from them, of a general character, for the region covered.

The scope of this study is tremendous and should the subcommittees be animated by the public spirit shown by the draft boards during the war, the investigation will prove exceedingly valuable.

The date for the returned questionnaires and reports from subcommittees to be in the F.A.E.S. headquarters in Washington, D. C., is Aug. 10.

The questionnaire is arranged as follows: I—General Information; II—Consumption and storage (a detailed report by months for a period of one year); III—Systems of storage and reclamations; IV—Spontaneous combustion, loss of heat value and degradation; V—Storage costs. The outline for the subcommittees' reports is arranged as follows: I—Consumption and storage (this is the data covered by the questionnaire); II—Regional coal requirements by classes of consumers; III—Transportation and storage; IV—Insurance on stored coal; V—Taxes on coal stored; VI—Financing storage of coal; VII—Employer's aid; VIII—Cost of storage; IX—Relation of storage to industry; X—Summary.

Clackamas River Project Under Construction

A gigantic hydro-electric development, involving the expenditure of $15,000,000, and the developing 105,000 hp., located about 60 miles southeast of Portland, Ore., in the region of the headwaters of the Clackamas River and its tributaries, is being constructed by the Portland Railway, Light & Power Co.

The project, as planned, is to be built in three units and involves the drainage of 318 square miles of forest land, belonging to the government, lying in the forest reserve in the heart of the Cascade Range of mountains, which has been leased from the government for fifty years.

The first unit necessitates the construction of a diversion dam on the Oak Grove Fork of the Upper Clackamas River, 29 miles above the site of the present plan at Faraday. There is available at the new site 430 sec-ft. of unregulated flow at an elevation of 2,035 ft. From the intake at this dam the water is to be conducted through a steel conduit a distance of six miles to the summit of Cripple Creek Knoll, which is 1,850 ft. above sea level. From this knoll penstocks will extend 900 ft. down the face of the cliff to the turbines in the power house on Three Links Creek.

Construction of the second unit involves the building of a three-mile tunnel to connect the upper fork of the Clackamas at Big Bottoms with the intake reservoir on Oak Grove Creek.

The third unit contemplates the building of a storage reservoir of 1,139 acres surface area at Timothy Meadows on Oak Grove Fork and one of 992 acres at Big Bottoms. The plant is expected to be in operation by July 1924.

Will Build Mine-Mouth Plant on Ohio River

Construction of a mine-mouth power plant having an ultimate capacity of 240,000 kw. is being planned by the Penn-Ohio Edison Co. The Ohio River Edison Co. will shortly start construction of a $10,000,000 steam plant using pulverized fuel on the Ohio River near Toronto, Ohio. The initial installment will consist of two 33,000-kva. units. The company controls about 7,000 acres of coal land immediately surrounding the site of the plant. The plant, when completed, will be leased to the Pennsylvania-Ohio Power & Light Co.

Should the industries of the United Kingdom revive, there might be difficulty in producing enough coal, as the hours of labor are seven now instead of eight as before the war. The coal mines are employing only about 10 per cent fewer men than at the time of maximum employment in 1920, and in November were employing practically the same number as in 1913, the year of greatest output (1,121,614 men in November and 1,127,890 in 1913). In this connection it might be well to recall that the output in 1922 is almost exactly the same as in 1906 (when it was 251,050,809 tons), but that it took only 874,161 men to produce it in 1906, as against about 1,100,000 men in 1922.

There is considerable agitation for a return to the eight-hour day, but labor has hitherto stoutly resisted any move in this direction. Without this longer working day the prospect at present is that, so far as Europe is concerned, output will not increase as fast as demand, according to a *Supplement to Commerce Reports for 1922.*

Government Extends Central Heating to White House

As a measure of combined economy and efficiency, the White House hereafter will be heated from the central heating plant of the State, War and Navy Building. At the same time that this connection is being made, another extension, from the central plant, is being run 300 ft. to the building occupied by the Civil Service Commission and this load also will be added when cold weather arrives.

The White House has been heated by two small and separate plants, one for the White House proper and the other for the adjoining executive offices. It has been difficult in severe weather to heat properly all portions of the buildings. The furnaces have been hand-stoked and have consumed about an average of 450 tons of anthracite annually.

The heating plant of the State, War and Navy Building has modern boilers and mechanical stokers and consumes bituminous coal. The load of the White House can be carried, according to the engineers in charge, at very little additional expense. The actual saving in money to be effected by the change will be at least $3,000 a year, it is estimated, while at the same time a more uniform supply of steam can be furnished. All parts of the White House can then be thoroughly heated, and the noise of the small furnaces will be eliminated which will add materially to the comfort of its occupants as well as to those in the executive offices.

The Civil Service Commission Building, which is being connected with the heating plant of the State, War and Navy Building, is small and can be added to the load without necessitating additional equipment. The saving in this change is estimated roughly at $4,000 annually. The plant of the State, War and Navy Building already is connected with two other nearby buildings occupied by units of the General Accounting Office, which it supplies with heat. Its electric plant furnishes current for the White House, the Civil Service Commission Building and the two Accounting Office buildings, while from a 10-ton plant it supplies ice to many government buildings.

Where practicable, the federal government is tending toward central heating plants in Washington. The Printing Office, the Botanic Gardens, and the Washington City Post Office recently were connected with the Capitol heating plant, which supplies the Capitol, the Library of Congress and the House and the Senate office buildings.

Alabama Power Co. Gets License for Cherokee Bluff Project

The Federal Power Commission has recently issued a license to the Alabama Power Co. for one of the largest and most important power projects in Alabama, to be located on the Tallapoosa River at Cherokee Bluffs about 10 miles above Tallassee. This development is one of a series of five or six projects which the company is planning to install on the Tallapoosa, designed to develop that stream completely, the ultimate installation to provide a maximum of approximately 450,000 hp.

The company will build a dam 105 ft. in height, creating a very large reservoir containing 25,000,000,000 cu. ft. of water. Two-thirds of the capacity of the reservoir will be used in storing water during the wet season for discharge during the low-water season. There will be developed 132,000 hp. in three 44,000 units at the dam, constituting an extremely valuable source of power to the company because its other plants lack this storage and during the dry season steam plants have to be called on to supply power. The extensive storage provided by this project will enable the company to furnish a large quantity of power during the dry season, when water power is scarce in all of the South Atlantic States.

J. William Peterson Dies at the Age of 48

J. William Peterson, until recently president and owner of the Richardson-Phenix Co., of Milwaukee, died suddenly of peritonitis on the morning of July 24.

He was born at Morris, Ill., on Dec. 16, 1875, finished his grammar school education in Chicago, and from that time on developed into a typical self-educated, self-made man eagerly devouring textbooks on subjects varying from art and engineering to finance and architecture. He was unable to go to high school, as it became necessary for him to support his parents. This he did by entering the electrical trade in Chicago, which gradually led up to electrical contracting.

In 1903 Mr. Peterson went to Cuba as a representative of the Westinghouse Electric & Manufacturing Co., but after two years returned to the United States to accept a position in the New York City office of the American Blower Co. After being with this company for a short time, he decided that the Corliss engine offered better opportunities, so he took a position in the New York City office of the Hooven-Owens-Rentschler Co. His experience with the Corliss-engine installations opened his eyes to the possibilities of automatic lubrication of power-plant machinery. Accordingly, early in 1908, he allied himself with the Sight Feed Oil Pump Co., of Milwaukee, becoming its first New York City agent and later taking entire charge of its product. He was at the same time operating his own company, known as the Peterson Engineering Co., specializing in large oiling-system installations, particularly in the hydro-electric field.

In 1910 he formed a partnership with the late Wilbur E. Richardson, and taking over the Phenix Lubricator Co., of Chicago, they created the Richardson-Phenix Co. Upon the death of Mr. Richardson shortly after, he established his headquarters in Milwaukee and in 1916 he merged the Peterson Engineering Co. and the Richardson-Phenix Co. In the latter part of 1921

J. WILLIAM PETERSON

a consolidation was effected with the S. F. Bowser Co., of Fort Wayne, Ind., manufacturers of a similar line, and he retired from business in January, 1922.

In engineering circles Mr. Peterson was prominent, being a member of the American Society of Mechanical Engineers, the American Society of Refrigerating Engineers and the National Association of Stationary Engineers.

He was one of Milwaukee's most prominent citizens, being associated with practically every large piece of civic work done in that city during the last decade. In Masonic circles he was always active and at the time of his death was on the Divan of the Shrine. He was president of the Tripoli Country Club and had just about completed supervising the building of the golf course and had completed his own beautiful home a short distance from the club. He is survived by his widow and one daughter.

Obituary

Thomas E. Tucker, founder and president of the Gem City Boiler Works, Dayton, Ohio, died July 20, following an operation. He was one of the most enthusiastic and loyal members of the American Boiler Manufacturers' Association, and his genial presence will be missed at their future meetings.

Walter Murray Brainerd, of 404 McDonough St., Brooklyn, N. Y., died of blood poisoning at South Nyack on July 24, having been ill for only a few days. He was a past-president of the Phoenix Association, No. 24, of the National Association of Stationary Engineers, and was at the time of his death a trustee of the Life and Accident Department of the N. A. S. E. For a number of years Mr. Brainerd had been a very active member of the Phoenix Association, and his sudden death was quite unexpected and will be a shock to his many associates who will miss his cheerful companionship.

New Publications

Smithsonian Institution, Annual Report of the Board of Regents, showing the Operation, Expenditures and Condition of the Institution for the year ending June 30, 1921. Government Printing Office, Washington, D. C. 6¼ x 9¼ in. Cloth.

The yearly reports of the Smithsonian Institution always contain extremely interesting and valuable appendices of a wide variety of interest. The 1921 report is not an exception to this rule. Beside the other articles and as the concluding appendix to the volume it contains a "Tribute to William Crawford Gorgas" by Brig. Gen. Robert E. Noble.

Heat Conservation Problems. (Waermewirtschaftsfragen) by L. Litinsky. Published by Otto Spamer, Leipzig, Germany. Printed in German. Paper; 194 pages.

A symposium on combustion and heat recovery problems in the ceramic, glass, coke and gas making industries, in which the design and operation of gas-fired retorts and regenerative furnaces are discussed. It is notable for its simple and logical presentation of formula for computing combustion efficiencies with gaseous fuels and for determining their heat value from chemical analysis. Interesting examples of heat balance are given. A chapter treats of the measurement of gas flow by means of orifices and nozzles, with temperature correction factors and methods for computing specific gravity. An appendix contains tabulations giving the mean specific heat of gaseous fuels, their chemical composition, heat value, air and furnace volume required and theoretical combustion temperature. The chapters dealing with chimney design, heat transmission and determination of chimney losses based on CO_2 content in the flue gases will be of interest to power-plant engineers.

Bulletin of the University of Wisconsin—Eng. Ser., Vol. IX, No. 1. Experiments on Loss of Head in Valves and Pipes of One-Half to Twelve Inches Diameter, by Charles Ives Corp and Roland O. Ruble.

Personal Mention

Carl J. Sittinger, who has been with John A. Stevens, consulting engineers of Lowell, Mass., has become associated with Stone & Webster, Inc., of Boston, Mass., as engineer in the electrical division.

John S. Isdale has resigned his position as electrical engineer to the New York Harbor Drydock Co. Inc., Rosebank, N. J., to become sales manager of the marine products branch of the Horno Electric & Manufacturing Co., Jersey City, N. J.

Tom March, in the Chicago office of the Combustion Engineering Corp., and **Robert Kuss** have been appointed to represent the Chicago Section of the A.S.M.E. on a subcommittee for the study of coal storage which is being conducted by the F.A.E.S.

R. T. Bratt, of The Superheater Co., New York City, gave an interesting half-hour talk on superheated steam before the Mott Haven Association, No. 47, of the N.A.S.E., on Tuesday evening, July 24. Delegations from many sister associations were present.

John R. Freeman has been recommended by the Committee on Awards and Prizes of the A.S.M.E. to the Council as the candidate for the Society Medal, for 1923, to be awarded for eminent service to engineering and manufacturing. Mr. Freeman is a past president of the A.S.M.E. and has rendered distinguished service along the lines of hydraulic engineering.

Business Notes

The **Public Service Corp.** of Quebec, has announced that the name of the Quebec Railway, Light, Heat & Power Co., will be changed to the Quebec Power Co.

The **Pure Carbon Co.**, Wellsville, N. Y., announces the establishment of a Chicago representative, Mr. John Nangle, with offices at 184 West Washington St., Chicago Ill.

The **Bundy Steam Trap Co.**, Nashua, N. H., announces the appointment of two new agents: H. M. Bush, 20 South Third St., Columbus, Ohio, for central Ohio; Sixt & Day, Guardian Bldg., Cleveland, Ohio, for Cleveland vicinity.

R. E. Spenser Geare, M.E., consulting engineer on power-plant and industrial machinery, has opened an office in the Witherspoon Building, Philadelphia, Pa. He is handling the following accounts: Bayley Manufacturing Co.; McEwan Brothers; Tow Motor Co.; Euclid Crane & Hoist Co. and The James Howden & Co.

The McClave-Brooks Co., Scranton, Pa., manufacturer of grates, stokers and combustion appliances, has appointed the Carbondale-Buffalo Co., Buffalo, N. Y., as its sales representative for New York State west of Rochester and for Ontario and Quebec in Canada. The I. N. Beeler Co., 504 City Bank Bldg., Syracuse, N. Y., will represent the company north of Kingston and east of Rochester. Sales in the remaining part of the state will be handled through the branch office in New York City.

Coming Conventions

American Chemical Society, Dr. Charles L. Parsons, 1709 G St. N. W., Washington, D. C. Convention at Milwaukee, Wis., Sept. 10-14.

American Institute of Electrical Engineers, F. L. Hutchinson, 29 West 39th St., New York City. Pacific Coast Convention at Del Monte, Calif., Oct. 2-5.

American Institute of Mining and Metallurgical Engineers; F. F. Sharpless, 29 West 39th St., New York City. Annual meeting at Ontario, Quebec, Canada, Aug. 20-31.

American Society of Mechanical Engineers, Calvin W. Rice, 29 West 39th St., New York City. Annual meeting at New York City, Dec. 3-6.

American Society of Refrigerating Engineers, William H. Ross, 35 Warren St., New York City. Nineteenth Annual Convention at New York City, Dec. 3-5.

Association of Iron & Steel Electrical Engineers; J. F. Kelly, 1007 Empire Bldg., Pittsburgh, Pa. Iron and Steel Exposition at Buffalo, N. Y., Sept. 24-28.

Illuminating Engineering Society, H. E. Mahan, Schenectady, N. Y. Convention at Fort William Henry Hotel, Lake George, N. Y., Sept. 24-28.

International Union of Steam and Operating Engineers; Dave Evans, 6334, Yale Ave., Chicago, Ill. Annual convention at Detroit, Sept. 10-15.

National Association of Practical Refrigerating Engineers; Ed. H. Fox, 914-25 East Jackson Blvd., Chicago. Fourteenth Annual Convention at Memphis, Dec. 12-16.

National Association of Stationary Engineers; Fred W. Raven, 417 South Dearborn St., Chicago, Ill. Annual convention and exhibition at Buffalo, N. Y., Sept. 10-15. Annual conventions and exhibitions of the State Associations scheduled as follows: **Pennsylvania**, at Buffalo, Sept. 9-10; J. N. Calvert, Crafton Sta., Pittsburgh, Pa. **New York**, at Buffalo, Sept. 9-10; W. T. Meinzer, Third St., near Warburton, Bayside, L. I., N. Y. **Minnesota**, at Duluth, Aug. 8-10; C. A. Nelson, 800 22d Rve. N. E., Minneapolis.

National Safety Council, W. H. Cameron, 168 North Michigan Ave., Chicago, Ill. Twelfth annual congress at the New Statler Hotel, Buffalo, N. Y., Oct. 1-5.

New England Association of Commercial Engineers; James F. Morgan, 53 Devonshire St., Boston, Mass. Power Show at Mechanics Bldg., Boston, Mass., Oct. 29-Nov. 3.

The New England Water Works Association; Frank J. Gifford, 715 Tremont Temple, Boston, Mass. Annual Convention at Burlington, Vermont, Sept. 18-21.

National Exposition of Power and Mechanical Engineering; Charles F. Roth, Room 1102, Grand Central Palace, New York City. Power Show, Dec. 3-8.

Society of Naval Architects and Marine Engineers, Daniel H. Cox, 29 West 39th St., New York City. Annual meeting at New York City, Nov. 8-9.

Universal Craftsman Council of Engineers; John F. Amos, P. O. Box 299, Rochester, N. Y. Convention at Powers House, Rochester, N. Y., Aug. 7-11.

Trade Catalogs

Stoker, Coxe—Combustion Engineering Corp., Broad St., New York City. Bulletin CB2 describes this traveling-grate stoker and illustrates fully its operation.

Stoker, Riley Underfeed, Super—Sanford Riley Stoker Co., Worcester, Mass. Catalog No. 81 gives descriptions with diagrammatic and photographic illustrations of this super-stoker and also of the Riley clinker grinder.

Compressors, Air & Vacuum Pumps—Pennsylvania Pump & Compressor Co., Easton, Penn. Bulletin No. 14 has 32 pages of descriptive matter and illustrations covering air compressors and vacuum pumps, power and steam driven straight-line and single-stage types up to 875 cu.ft.

Heaters, Coolers, Heat Exchangers—Croll-Reynolds Engineering Co., Inc., 95 Liberty St., New York City. Bulletin E shows the designs of heaters for feed water and for use with bleeder-type turbines as well as for other purposes, and describes coolers for water, air, oils, gases and other industrial purposes.

Fuel Prices

BITUMINOUS COAL

The following table shows the trend of the spot steam market in various coals (mine run bases, f.o.b. mines):

Coal	Market Quoting	July 23, 1923	July 30, 1923
Pool 1,	New York	$3.25@3.50	$3.25@3.50
Smokeless,	Columbus	3.00@3.50	2.75@3.25
Clearfield,	Boston	2.00@2.75	2.00@2.75
Somerset,	Boston	2.25@3.00	2.25@3.00
Kanawha,	Columbus	1.75@2.00	1.75@2.00
Hocking,	Columbus	1.75@2.00	1.75@2.00
Pittsburgh No. 8	Cleveland	1.90@2.00	1.75@1.90
Franklin, Ill.	Chicago	2.75@3.25	2.75@3.00
Central, Ill.	Chicago	2.00@2.25	2.00@2.25
Ind. 4th Vein,	Chicago	2.50@2.75	2.50@2.75
West Ky.,	Louisville	1.60@1.85	1.35@1.85
S. E. Ky.,	Louisville	1.50@2.00	1.50@2.00
Big Seam,	Birmingham	1.75@2.15	1.75@2.15

FUEL OIL

New York—Aug. 2, light oil, tank car lots, 28@34 deg. Baumé, 4c. per gal.; 36@40 deg. 4½c. per gal., f.o.b. Bayonne, N. J.

Chicago—July 14, 24@26 deg. Baumé, $1.97 per bbl.; 32@36 deg., $2.27 per bbl., tank cars.

St. Louis—July 24, tank-car lots, f.o.b. St. Louis; 24@26 deg., $1.75 per bbl.; 26@28 deg., $1.80 per bbl.; 28@30 deg., $1.85 per bbl.; 32@36 deg., gas oil, 4@4¼c. per gal.; 36@40 deg., distillate, 4¼@4⅜c. per gal.

Pittsburgh—July 26, f.o.b. local refinery, 30@34 deg., fuel oil 4⅞c. per gal.; 36@40 deg., fuel oil, 5c. per gal.; 34 deg., neutral 7¼c. per gal.

Dallas—July 28, f.o.b. local refinery, 26@30 deg., $1.38 per bbl.

Cincinnati—Aug. 2, tank car lots f.o.b. local refinery, 26@30 deg. Baumé 4¼c. per gal.; 30@32 deg., 4⅜c. per gal.; 38@42 deg., distillate, 6c. per gal.

New Plant Construction

PROPOSED WORK

Ala., Mobile—The Acme Oak Flooring Co,, D. N. P. Hackney, Mgr., is in the market for a 300 hp. engine and mechanical equipment.

Ark., Van Buren—The city, C. M. Woffard, Secy. Bd. of Improvements, voted $210,000 bonds for waterworks improvements, including pumps, tanks, c.i. pipe, filtration plant, hydrant, valves, etc. W. L. Winters, 700 South 20th St., Ft. Smith, Engr.

Calif., Emeryville—The Standard Underground Cable Co., First National Bank Bldg., San Francisco, is having plans prepared for the construction of a factory, including 100 x 300 ft. main building, also power house and warehouse. Estimated cost $200,000. A. Prack, c/o Westinghouse Electric & Mfg. Co., Emeryville, Engr.

Calif., Los Angeles—The A. C. Blumenthat Co., Loew State Bldg., is having plans prepared for the construction of a 12 story, 51 x 150 ft. mercantile building, at 816 South Bway., for the Wurlitzer Co., 117 East 4th St., Cincinnati, Ohio. Estimated cost $1,000,000.

Calif., Los Angeles—A. McCartney Co., c/o J. H. Dunn, Archt., Merchants' National Bank Bldg., is having plans prepared for the construction of a 5 story hotel and stores building on Temple St. and Broadway. Equipment detail not reported.

Calif., Los Angeles — Wheeler & Weingand are having plans prepared for the construction of a 5 story, 98 x 103 ft. hotel on Santa Monica Blvd. Estimated cost $250,000. L. L. Jones, 602 Grosse Bldg., Archt. Equipment detail not reported.

Calif., San Francisco—The San Francisco Protestant Orphan Asylum, c/o Bliss & Faville, Archts., Balboa Bldg., are having plans prepared for the construction of an orphanage, consisting of a 3 story administration building, six 2 story cottages and a 1 story laundry and power house. Estimated cost $350,000. Equipment detail not reported.

Calif., San Jose—The County of Santa Clara, H. A. Pfister, Clk., will soon award the contract for the construction of a power plant on the county hospital grounds. Estimated cost $90,000. Binder & Curtis, 255½ South 1st St., San Jose, Archts. Noted May 29.

Calif., San Jose—Notre Dame College is having plans prepared for the construction of a group of college buildings. Estimated cost $600,000. J. J. Donovan, 1916 Bway., Oakland, Archt. Equipment detail not reported.

Calif., Santa Monica—Mick & Doyle are having plans prepared for the construction of a 5 story, 208 x 240 ft. apartment building on Ocean Ave. Estimated cost $500,000. Walker & Eisen, 326 Pacific Finance Bldg., Los Angeles, Archt. Equipment detail not reported.

Calif., Tracy—The city, F. L. Frerichs, Clk., will receive bids until Aug. 9 for a sewage disposal plant, including pump house with gasoline motor and 2 pumps. C. F. Smith, 516 Santa Barbara Rd., Berkeley, Consult. Engr.

Colo., Loveland—The city voted approval of bond issue for the construction of a municipal hydro-electric power plant on the Big Thompson River, near here, although temporarily restrained by the court.

Conn., Bridgeport—D. M. Read Co., 1120 Main St., plans the construction of a 6 story department store building on Broad and John Sts. Estimated cost $1,000,000.

Conn., Bristol—The Bristol Hospital, Inc., F. F. Barnes, Pres., plans the construction of a 3 story hospital. Estimated cost $450,000. C. S. Palmer, 114 Whitney Ave., New Haven, Archt. Equipment detail not reported. Noted Feb. 27.

Conn., Leesville (Moodus P. O.)—The Connecticut Power & Light Co., East Hampton, plans improvements to Leesville Dam on the Salmon River, including raising from present height of 18 ft. to 78 ft., etc. Estimated cost $500,000.

Conn., Mansfield—The Mansfield Training School and Hospital, C. L. La Moure, Supt., is having plans prepared for the construction of additions to hospital, consisting of Nurses' home building, hospital ward, and boys' dormitory building. Estimated cost $440,000. Cudworth & Thompson, Thayer Bldg., Norwich, Archts. Equipment detail not reported.

Fla., Ocalo — The Marion Improvement Co. is having plans prepared for the construction of a 10 story, 93 x 100 ft. hotel on Magnolia St. Estimated cost $550,000. F. J. James, Citizens Bank Bldg., Tampa, Archt. Equipment detail not reported.

Fla., Pahokee—The town plans $90,000 bond issue, for the installation of waterworks, ice plant, etc.

Ga., Savannah—The Comrs. of Chatham County will receive bids until Sept. 20, for furnishing oil burning land dredge, equipped with one cu.yd. bucket, operated by at least 45 hp. internal combustion engine.

Ill., Fairfield—The City Clk. is in the market for a large size boiler for electric light plant.

Ill., McLeansboro—The city plans election Aug. 20, to vote $31,500 bonds for a 400,000 gal. per day filtration plant, pipes, fire hydrants, new generator set, etc. Noted Jan. 23.

Ill., Savanna—The Carroll County Drainage & Levee Dist. 1, H. P. Greison, Secy., received bids for the construction of a pumping plant, including a 30 in. centrifugal pump, from F. Mutchmore, Savanna, $13,252; Farrar Pump & Machinery Co., Granite Bldg., St. Louis, Mo., $21,600. Noted July 10.

Ia., Ames — The Iowa State College is having plans prepared for the construction of a Memorial Union building at the state college campus. Estimated cost $1,000,000. Pond & Pond, 64 East Van Buren St., Chicago, Ill., Archts. Equipment detail not reported.

Ia., Cedar Rapids—The county auditor, Marion, will receive bids until Aug. 22, for the construction of a 3 story court house, on Municipal Island, separate bids for heating and ventilating system, elevators, etc. Estimated cost $750,000. J. W. Royer, Flat Iron Bldg., Urbana, Ill., Archt. Noted Nov. 21, 1922.

Kan., Wichita—Wheeler, Kelly & Hagny, 120 South Market St., plans the construction of a 7 story store and office building on Market St. Estimated cost $500,000.

Md., Baltimore—The Bernheimer-Leader Stores, L. C. Coblens, Pres., Howard and Lexington Aves., plan the construction of an 8 or 9 story department store building. Estimated cost $1,500,000.

Md., Baltimore—The Consolidated Gas, Electric Light & Power Co., Lexington and Liberty Sts., plans to build a 47 x 144 ft. building at Klomans St. and Western Med. R.R. Estimated cost $103,000. Equipment detail not reported.

Mass., Wakefield—The Bd. of Light Comrs. is having plans prepared for the construction of the new sub-station. Lockwood, Greene & Co., 24 Federal St., Boston, Consult. Engrs.

Mich., Detroit—The Fairbairn Hotel, P. R. Bierer, Mgr., 381 West Grand Blvd., is having plans prepared for the construction of an 8 story, 120 x 157 ft. hotel, including oil heating plant, elevators and equipment, on East Columbia St. Estimated cost $1,250,000. Engineer and architect not announced.

Minn., Blue Earth—The city voted $75,000 bonds to extend municipal heating plant mains.

Mo., Kansas City—The Kansas City Machine Works, 1303 West 8th St., is in the market for a Fairbanks-Morse oil engine, 50 to 200 hp., 3 phase, 60 cycle, 2300 r.p.m.

Mo., St. Louis—O. J. Dieckmann, 609 Security Bldg. (machinery and equipment), is in the market for an air compressor, 350 cu.ft. capacity, single stage, belt driven.

Mo., Stockton—The city will soon receive bids for the rebuilding of dam and installation of pumping equipment, distribution of mains, etc. Estimated cost $60,000.

Mo., Waco—The Alleghany Mining Co., M. Andrews, Supt., is in the market for a 150 hp. steam boiler.

Mo., Webb City—The Interurban Ice Co., A. Daniels, Pres., is in the market for three 250 hp. steam boilers.

N. Y., Jamestown — R. G. Roberts, Roberts Bldg., is in the market for steam heating plant and system for Roberts building.

N. Y., Middletown — The State Hospital Comn., Capitol, Albany, will receive bids until Aug. 8, for new electric elevator and elevator shaft for storehouse at the State Homeopathic Hospital here.

N. Y., New York—Bd. Educ., W. H. Gompert, Archt., Flatbush Ave. Extension and Concord St., Brooklyn, will receive bids until Aug. 10 for installing heating, ventilating and temperature regulating apparatus in Julia Richman High School at 2nd Ave. and 67th St.

N. C., Elizabeth City—The city plans extensive improvements to electric light plant, waterworks system, also paving. Estimated cost $300,000. J. Bray, Engr.

N. C., Method—The Meredith Baptist College, C. E. Brewer, Pres., 128 North Blount St., Raleigh, is having plans prepared for the construction of college buildings, here. Estimated cost $1,000,000. Wilson & Berryman, Wilson, Archts. Equipment detail not reported. Noted May 23, 1922.

N. C., Sharpsburg—The town, E. H. Jones, Clk., plans extending and enlarging electric light system. Estimated cost $10,000.

Ohio, Massillon—The Ohio Public Service Co. plans the construction of a power sub-station, 30,000 kw. capacity, on Jarvis Ave. Estimated cost $150,000.

Okla., Enid—The City Ice Co. plans the construction of a 50 ton ice plant, raw water system, also five retail ice stations. Total estimated cost $75,000.

Pa., Altoona — The Bd. Educ., W. F. Eberle, Pres., 6th Ave. and 15th St., will receive bids until Aug. 20, for the construction of an addition to power and heat plant, including furnishing and installing 1 water tube boiler of B & W or equal approved type, with stoker, economier, stack and ash handling equipment; 2 kw. turbo generators, leads, switchboards, electrical feeders, underground duct transformers, vaults, wiring, etc. Stewart A. Jellet Co., 1200 Locust St., Phila., Engr.

Pa., Phila.—L. H. Cahan, 1324 Walnut St., is having plans prepared for the construction of a 22 story, 100 x 100 ft. hotel on Spruce and Broad Sts. Estimated cost $4,000,000. H. E. Kennedy, 1324 Walnut St., Archt. Equipment detail not reported.

Pa., Tarentum—L. R. Hartley, Bor. Secy. will receive bids until Aug. 10 for additions and alterations to the electric light plant. R. E. Walters, Bor. Engr.

Tex., Bronte—F. E. Brown and C. C Holder have had plans prepared and wil receive bids about Aug. 25, for the construction of a light and power plant, including a 50 hp. gasoline engine, generator and power lines. Estimated cost $50.000.

Tex., Mercedes—The city, J. E. Haynes, Mayor, plans election to vote $150,000 bonds for the construction of a municipal electric light and power plant and water plant.

Va., City Point—Wilson Hack Co. is in the market for a 150 hp. boiler, 6-8-20 in. low pressure, gate valves and 1 ton electric hoist.

Wash., Seattle — The Pacific Steamship Co. has purchased the former site of the Skinner & Eddy Shipyards, and plans to erect ocean shipping terminals, including 3 piers, large warehouses and office building. Estimated cost from $3,000,000 to $4,000,000. The terminals will be completely equipped with electrically operated, cargo handling equipment.

Wisconsin — Mead & Seastone, Engrs., Journal Bldg., Madison, are receiving bids on transformer, switchboard, structural steel, 2 steel penstocks, 6 tainter gates, 12 x 14, sluice gates for power plant at Caldron Falls, for the Northeastern Power Co., 559 Marshall St., Milwaukee.

Wis., Appleton—The City Water Comn., F. Morris, Secy., is receiving bids for two 25 kw. generators for pumping station.

Wis., Athens—The village, C. F. Hamilton, Clk., voted $75,000 bonds for the installation of new waterworks and sewerage systems, including pumping equipment.

Wis., Milwaukee—The Jersey Ice Cream Co., 387 11th Ave., plans the construction of a 2 story factory on Mitchell St. Estimated cost $40,000. Refrigeration machinery will be required.

Wis., North Milwaukee — Fred Luber, Archt., c/o Milwaukee Electric & Light Co., owner, 2nd and Sycamore Sts., Milwaukee, is receiving bids for the construction of a 2 story, 37 x 67 ft. sub-station, including transformers. Estimated cost $25,000.

Ont., North Bay — The Hydro Electric Power Comn., 190 University Ave., Toronto, plans to rebuild hydro-electric power substation and distribution station, destroyed by fire. Estimated cost $100,000 to $150,000. F. A. Gaby, Ch. Engr. Owner will purchase electrical equipment, consisting of transformers, switches, etc.

Ont., Ottawa—The Dept. Public Works, R. C. Desrochers, Secy., will receive bids until Aug. 9, for furnishing and installing new boilers at Public Bldg., Regina, Sask., until Aug. 10, for boilers and heating equipment in public building at Weyburn, Sask.

Ont., Toronto—The city, C. A. Maguire, Mayor, City Hall, will receive bids until Aug. 21, (extended from July 24), for furnishing and installing two 2,880,000 imp. gal. electrically driven, centrifugal sewage pumps. Estimated cost $30,000. R. C. Harris, City Engr. Noted July 17.

Que., Montreal—The Ottawa River Power Co., Ltd., 145 St. James St., is in the market for extensive development equipment, including power and transmission machinery.

CONTRACTS AWARDED

La., New Orleans—The U. S. Engineers Office, War Dept., awarded the contract for the construction and delivery of two 20 in. dredge pumps to the Ellicott Machine Corp., Bush St., Baltimore, Md., $11,200. Noted June 19.

Minn., Moorhead—The Fairmont Creamery Co., L. E. Herz, Secy., 12th and Dodge Sts., Omaha, Neb., awarded the general contract for the construction of a creamery, including engine and boiler house, to T. F. Powers & Co., 429 9th St., Fargo, N. D. Complete cost about $135,000.

Mo., Jefferson City—Lincoln University, New York Life Bldg., Kansas City, awarded the contract for installing new boilers, resetting old boilers and laying steam lines, etc., to Eichler Heating Co., Railway Exchange Bldg., St. Louis. Noted July 17.

Mo., St. Louis—W. Goldman, 6343 Waterman Ave., awarded the contract for the construction of a 6 story, 146 x 148 ft. theatre, store and office building on Grand Blvd. to P. J. Bradshaw, International Life Bldg., St. Louis. Estimated cost $600,000. Equipment detail not reported. Noted March 13.

N. C., Mocksville—The city awarded the contract for the installation of a lighting and power plant to the Electrical Constr. Co., Charlotte. Estimated cost $15,000.

Tex., Dallas—D. David, 2924 Park Row, awarded the contract for the construction of a 2 story, 75 x 100 ft. warehouse and cold storage building on Laws River and Griffin Sts. to Hickey & Montgomery, Magnolia Bldg., $40,000.

Wis., Fort Atkinson — The city, W. D. Leonard, Clk., awarded the contract for the construction of a pumping station and 300,000 gal. reservoir to T. S. Willis, 330 Hayes Block, Janesville, $17,910. Noted July 17.

Wis., Madison—A. J. Sweet, 639 West Wilson St., awarded the contract for the construction of a 2 story, 50 x 95 ft. cold storage plant to W. H. Deason, Washington Bldg. Estimated cost $50,000. Owner is in the market for a 20 ton ice machine. Noted May 22.

Wis., Peshtigo — The North Eastern Power Co., 559 Marshall St., Milwaukee, will build by day labor a new 4,000 kva. unit in power plant, also strengthening old dam, including abutments, gates, etc. Estimated cost $50,000. Noted June 26.

Ont., Hamilton—The Canadian Westinghouse Co., Traders Bank Bldg., Toronto, awarded the contract for the construction of a 3 story, 200 x 804 ft. electric manufacturing plant on Aberdeen Ave. to the W. H. Yates Constr. Co., 17 Main St., Hamilton, $200,000. This is the first unit of an extensive program, estimated at $1,250,000. Noted June 12.

Ont., Timmins — The Hollinger Consolidated Gold Mines, Ltd., awarded the general contract for the construction of a hydro-electric power plant on the Abitiki River at Island Portage, consisting of dams, power house, 3½ mi. railway spur, etc., to W. Arrol & Sons, Ltd., St. Catharines. Total estimated cost $4,000,000 to $5,000,000. Kerry & Chace, Ltd., Engrs., Confederation Life Bldg., Toronto, are receiving bids on turbines, generators, sluice gates, cranes, transformers, switches, 80 mi. transmission line and electrical equipment. Noted Dec. 19, 1922.

Que., Montreal—The city, E. Gauthier, Asst. Clk., awarded the contract for furnishing a 6,000,00 gal. pump for the Notre Dame de Grace pumping station to E. Laurie Co., 243 Bleury St., $20,900.

ADDITIONAL OPPORTUNITIES

Employment Equipment
Miscellaneous Business

See the

SEARCHLIGHT SECTION

This Issue, Pages 126 to 131